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3.0 PRINCIPAL DESIGN CRITERIA

3.1 PURPOSES OF INSTALLATION

The Idaho Spent Fuel (ISF) Facility is designed for dry, interim storage of various spent nuclear fuel (SNF) types until their ultimate transfer to a permanent repository. The SNF is placed in baskets, sealed in stainless-steel canisters, and stored within vertical storage tubes. The stored SNF is fully retrievable and capable of being transported offsite to a permanent storage facility when it becomes available.

3.1.1 Materials to be Stored

The ISF Facility stores three basic types of SNF: Peach Bottom fuel elements, TRIGA, and Shippingport reflector modules and rods. The following sections describe the physical and thermal characteristics of this material. Table 3.1-1 presents the physical dimensions of the stored fuel types. Chapter 7 describes the radiological source terms of the different fuel types and activated non-fuel components.

In contrast to typical commercial reactor fuels, the effects of temperature and operating conditions on the long-term behavior of the fuel cladding are not well documented for the particular fuel types stored at the ISF Facility. Furthermore, the DOE has identified some fuels to be stored that are known to be damaged (e.g., Peach Bottom fuel with attached removal tools). Therefore, Foster Wheeler Environmental Corporation (FWENC) has chosen not to rely on the fuel cladding as a confinement barrier in the design of the ISF Facility. Instead, all fuels will be placed in sealed canisters, consistent with the fuel canning requirements in 10 CFR 72.122(h)(1) and Interim Staff Guidance 1, *Damaged Fuel* (Refs. 3-1 and 3-30). Explicit canister, basket, and fuel clad temperature limits are identified for handling and storage operations at the ISF Facility. These limits and their bases are discussed in Chapter 4.

3.1.1.1 Peach Bottom Fuel Elements

Peach Bottom Unit 1 was a graphite-moderated, helium-cooled high-temperature, gas-cooled reactor (HTGR) producing 115 megawatts (MW) that operated from March 1966 until October 1974. Commercial operation of Core 1 ran from June 1967 until October 1969 for a total of 451.5 effective full power days (EFPD), the equivalent of 30,795 MW days per metric ton of initial heavy metal (MWd/MTIHM). Core 2 ran from July 1970 until October 1974 for a total of 897.4 EFPD or 72,717 MWd/MTIHM. Core 1 operated for approximately half of the expected time because of unanticipated fuel swelling and cracking. This problem was addressed by using a different fuel particle design for Core 2 (Ref. 3-2).

The basic fuel element, manufactured by GA Technologies, is a solid semi-homogeneous type in which graphite serves as the moderator, reflector, cladding, fuel matrix, and structure. As shown in Figure 3.1-1, the standard fuel element consists of a bottom connector, sleeve, screen, internal fission product trap assembly, lower reflector piece, fuel compacts, spines, burnable poison compacts (in selected elements), fuel cap, and upper reflector assembly. The bottom connector and sleeve are joined by a silicon braze and form the main barrier against fission product leakage from the fuel element. The fuel cap is a graphite disk that slips loosely into the upper end of the sleeve. All three of these components (bottom connector, sleeve, and fuel cap) are made of graphite with a helium permeability of $\leq 3 \times 10^{-3}$ cm^2/s and an effective permeability to gaseous fission products of approximately 10^{-5} cm^2/s at reactor conditions (Ref. 3-3).

From bottom to top, the screen, internal trap assembly, lower reflector piece, fuel compacts with spines, and fuel cap are stacked within the sleeve and are supported by the bottom connector. The lower reflector piece is a 3-inch-long graphite cylinder. The annular fuel compacts are stacked on cylindrical graphite spine sections approximately 30 inches long and 1.75 inches in diameter. There are two types of spines: one of solid graphite and one with a 0.89-inch-diameter hole designed to contain burnable poison compacts. The screen, used to trap any charcoal granules that might be released from the graphite body of the internal trap, is made of 18-8 stainless steel. The upper reflector is a machined graphite component that is threaded and secured into the sleeve of the fuel element with furnace-cured carbonaceous cement. The upper end of the reflector piece is machined to engage with fuel handling equipment. A ¼-inch-diameter hole down the centerline of the reflector serves as an inlet channel for purge gas. A porous plug cemented and retained within the upper reflector provides a controlled pressure drop for inflowing purge gas.

The Core 1 fuel compacts consist of carbides of thorium and uranium enriched to 93.15 percent ^{235}U at the beginning of life (BOL) and uniformly dispersed as coated particles in a graphite matrix. Total carbon within the carbide substrates is between 11 and 16 percent by weight at BOL. The pyrolytic carbon-coated particles are 210 μm and 595 μm for fissile and fertile particles, respectively, with coating thicknesses of 55 ± 10 μm. The size distribution of the particles was designed to ensure that the volume fraction of the coated particles did not exceed 30 percent of the total compact volume.

Cylindrical burnable poison compacts were placed in hollow spines of some fuel elements. Each compact contains 0.436 ± 0.030 g of natural boron in the form of zirconium diboride pressed into a graphite matrix. The maximum particle size of the zirconium diboride was 100 μm (Ref. 3-3).

Core 2 fuel elements are essentially the same as Core 1 elements aside from the pyrolytic coating. Where Core 1 fuel particles have a single coating, Core 2 particles have an inner low-density pyrolytic coating surrounded by an outer isotropic coating. The particles are 340 μm (fissile) and 630 μm (fertile) with a total coating thickness of 90 to 130 μm (Ref. 3-3).

There are four types of fuel elements that differ in isotopic content for both Core 1 and Core 2. This variation in fuel was achieved by loading different kinds of fuel compacts into the elements. Table 3.1-2 and Table 3.1-3 describe these compacts.

The loading sequence of the compacts determine the type of fuel element they form. Table 3.1-4 describes the characteristics of the four fuel element types (Ref. 3-3).

Core 1 operated for 451 EFPD, or approximately half of its 900 EFPD design life, before fuel failure problems required it to be replaced. Failed fuel occurred when the internal fuel compacts swelled and distorted, cracking the outer sleeve. This failure mechanism affected 90 fuel elements (Ref. 3-3). The damaged fuel could not be removed normally because the installed lifting fixture depended upon the integrity of the outer sleeve. Consequently, removal tools were fabricated to extract the damaged elements from the reactor. As shown in Figure 3.1-2, each removal tool is a stainless steel cylindrical sleeve with an aluminum-lifting fixture that surrounds a damaged fuel element. Six spring fingers engage the bottom of the element to allow lifting.

Upon removal from the reactor, each intact fuel element was placed in an aluminum canister with a stainless-steel liner (Figure 3.1-3). The canister was sealed with double O-rings and backfilled with helium. Failed fuel elements, together with their removal tools, were also sealed in these canisters (Figure 3.1-4). After backfilling, the canisters were leak checked. Any leaking canisters were placed into a second sealed aluminum salvage canister (Figure 3.1-5). The Core 1 elements stored at the ISF Facility consist of both intact and failed fuel elements. The innermost of these containers are expected to be contaminated but not activated due to the low neutron fluence of the Core 1 fuel.

The Core 2 elements were initially placed in the same aluminum canisters described above, but were later transferred to carbon steel storage canisters measuring 18 inches in diameter and 11 feet long. These canisters were enclosed by lids that reduced air exchange but did not seal the contents. To accommodate these canisters, the upper 18 inches of each element's top reflector was removed. This cropping did not damage the fuel portion of the elements but did eliminate the lifting fixture used for fuel handling.

A total of 1601.5 Peach Bottom fuel elements will be processed and stored at the ISF Facility. Forty-six aluminum storage baskets, containing 814 sealed aluminum storage canisters with stainless-steel liners that house 813 individual Peach Bottom 1 elements, are currently in dry storage in underground vaults at Idaho Nuclear Technology and Engineering Center (INTEC), adjacent to the ISF Facility. An additional 1.5 elements are stored within the Fuel Examination and Cutting Facility in a dry, stable condition. The remainder of the 1601.5 elements are from Peach Bottom 2. The elements are packaged dry into 70 unsealed, carbon-steel canisters within a fuel storage area at INTEC.

No more than 10 Peach Bottom elements are placed in a single ISF canister for storage in the ISF Facility.

Chapters 4 and 8 discuss the maximum fuel temperatures that occur during fuel handling and storage under normal, off-normal and accident conditions.

3.1.1.2 TRIGA Fuel Elements

The TRIGA reactor is a light-water-cooled, graphite or water-reflected reactor designed for training, research, and isotope production. TRIGA fuel elements, manufactured by GA Technologies, are a solid homogeneous mixture of uranium-zirconium hydride alloy with aluminum, stainless steel, or incoloy cladding. Only the standard aluminum clad and standard stainless steel clad elements are included in the ISF storage scope.

Figure 3.1-6 shows the general arrangement of a TRIGA fuel element. The fuel rod is axially centered in the element with a graphite moderator slug at each end. Burnable poison disks, if present, are placed between the fuel rod and the graphite. There is no bonding material between the fuel and the cladding. Fixtures are heliarc welded to the top and bottom ends of the cladding to encapsulate all of the internal pieces (Ref. 3-4).

The lower-end fixture of the fuel element is designed to guide the element into the bottom support plate of the reactor core. The upper-end fixture consists of an attachment point for a fuel-handling tool (Ref. 3-5).

There are two types of aluminum-clad elements, differentiated only by the length (either 14 or 15 inches) of their active fuel. All of the aluminum-clad fuel contains approximately 8 percent by weight uranium enriched to 20 percent ^{235}U. Instrumented aluminum-clad elements are similar to the standard elements except for an aluminum tube welded to the upper-end fitting to allow the passage of thermocouple wires.

Within the scope of the ISF project, there is one type of stainless-steel clad TRIGA element that will be handled. Uranium content in this type of element varies from 8 to 9 percent by weight enriched to 20 percent ^{235}U. Instrumented stainless steel clad elements are similar to the standard elements except for a stainless-steel tube welded to the upper-end fitting to allow passage of thermocouple wires.

The TRIGA SNF to be packaged in this project nominally consists of 1285 stainless steel clad elements and 315 aluminum clad elements. There are currently 1159 TRIGA fuel rods stored at the INTEC. All fuel elements will be delivered dry and are expected to be in good condition when received at the ISF Facility.

When stored in the ISF Facility, a single storage canister contains up to 108 TRIGA fuel elements. The TRIGA fuel elements contain no control components but some contain instrumentation that is likely contaminated and activated. These instrument packages are integral to the elements and remain with them during storage.

Chapters 4 and 8 discuss the maximum fuel temperatures that occur during fuel handling and storage under normal, off-normal and accident conditions.

3.1.1.3 Shippingport Fuel Modules

The Shippingport Light Water Breeder Reactor (LWBR) was an experimental reactor that utilized a seed-and-blanket fuel module arrangement manufactured by the Bettis Atomic Power Laboratory (operated by Westinghouse Electric Corporation). A hexagonal stationary blanket module surrounded a central hexagonal movable seed that provided reactivity control. As shown Figure 3.1-7, the LWBR core contained 12 seed and blanket modules surrounded by 15 reflector modules used to limit neutron losses from the core.

The LWBR core operated for more than 29,000 effective full power hours before final shutdown in 1983. Before shipping to the Expended Core Facility (ECF), fuel modules were partially disassembled to fit into the shipping containers. The disassembly involved removing the support shaft from the seed modules, the support tube, seal block, stub shaft, and guide tube extension from the blanket modules, and the seal block from the reflector modules. Because removing these items also eliminated the lifting fixtures, all modules were fitted with a shipping plate attached to the top base plate.

At the ECF, 12 modules (4 of each type) were further disassembled to provide fuel rods for core evaluation and proof-of-breeding tests. The top and bottom base plates were removed, allowing the required rods to be withdrawn for testing. Stabilization clamps were then fitted around the modules to prevent the remaining rods from falling out during movement. The clamps consist of a top and bottom section connected by 6 external tie bars. One reflector also had part of the outer shell removed.

The ISF Facility will store 11 intact reflector modules, 4 clamped reflector modules, and 127 loose reflector rods. All loose rods are received within a single incoming container and are to be transferred to and stored within a single ISF canister.

There are two types of reflector module: Reflector IV and Reflector V. Figure 3.1-8 shows the general arrangement of Reflector V. The only difference between the two is external geometry; this difference accommodated placing the hexagonal seed/blanket modules in a cylindrical pressure vessel. Each reflector module contains rods of stacked unenriched nonfissile ThO_2 pellets clad in 0.832-inch zircaloy-4 tubes. The modules contain no control components.

There are 9 Reflector IV modules, 3 of which are clamped. The number of rods within the modules varies between 152 and 228, and the weights vary between 4933 and 5200 pounds. There are 6 Reflector V modules, 1 of which is clamped. The number of rods within the modules is either 129 or 166 with weights from 4028 to 4204 pounds. Each reflector module, whether intact or clamped, resides in its own storage canister. Unlike the Peach Bottom and TRIGA fuels, each Shippingport fuel rod contains helium initially pressurized to 1 atmosphere. The total gas volume for each rod is 2.7 cubic inches.

Chapters 4 and 8 discuss the maximum fuel temperatures that occur during fuel handling and storage under normal, off-normal and accident conditions.

3.1.1.4 Decay Heat

To determine the decay heat output of each type of fuel to be stored, FWENC used ORIGEN2, a widely used computer code that estimates the inventory of fission products, activation products, and actinides of nuclear fuel at any point in its lifetime (Ref. 3-6). Each ORIGEN2 run requires the input of detailed data for the fuel core composition and the power history of the reactor. In particular, nuclear cross-section libraries for each fuel type are required for the particular reactor.

The DOE applied ORIGEN2 to determine an initial radionuclide inventory for each fuel type. With this information, FWENC further decayed the fuels beyond July 1, 2004, the earliest anticipated date for fuel handling operations at the ISF Facility. ORIGEN2.1 was used to adjust the activities of each of the actinides, activation products, and fission products to yield an isotope activity-specific decay heat value. The code then summed those values to provide the decay heat per SNF element or module. Figure 3.1-9 through Figure 3.1-13 depict decay heat as a function of time per element for each type of fuel stored at the ISF Facility. TRIGA fuels exhibit the highest degree of variation from the averages presented; individual TRIGA elements can generate up to 2 W/element decay heat.

3.1.2 GENERAL OPERATING FUNCTIONS

3.1.2.1 Overall Facility Operation

Operations are organized into four general categories, each associated with a particular area of the facility. These are: 1) cask receipt and movement, 2) fuel packaging, 3) canister closure operations, and 4) canister storage. Cask receipt takes place in the Cask Receipt Area, fuel packaging in the Fuel Packaging Area (FPA), canister closure operations in the Canister Closure Area (CCA), and canister storage in the Storage Area. The four areas are interconnected by a Transfer Tunnel, which is used to move casks and canisters from one area to another during operations. A fifth area for the handling of onsite generated waste is discussed in Section 3.1.2.3. A summary description of operations is found below, followed by a more detailed description of specific activities in each major area of the ISF Facility.

Fuel receipt begins at the facility boundary security fence. The transfer cask is off-loaded inside the Cask Receipt Area and transported by the cask trolley to the FPA. At the FPA cask port, the transfer cask is opened to allow the fuel receipt canister to be removed. These fuel receipt canisters are opened, and the fuel elements removed, inspected, inventoried, and placed into new baskets and storage canisters. These loaded canisters are then transported inside the shielded, seismically qualified canister trolley to the CCA where the canister closure welds are made, and the canister is vacuum dried, inerted with helium, and helium leak tested. With the helium inerting, helium leak testing, and nondestructive testing of the canister closure welds complete, the canister is ready for storage.

The loaded canister is transferred from the CCA to the Storage Area using the same canister trolley. At the port in the Storage Area, the loaded canister is handled using the canister handling machine (CHM) and placed into a storage tube location inside the storage vault. The vault provides passive natural convection cooling. Air enters the vault and decay heat from the fuel causes the air to rise, where it is directed upward through annular gaps around the tubes, exiting to the charge face floor. No active systems are required to maintain the airflow.

3.1.2.2 Transportation

SNF enters the ISF Facility in the transfer cask aboard a transporter that moves the fuel from the nearby INTEC facility. The transfer cask is not certified in accordance with 10 CFR 71 because the entire movement occurs within the DOE INEEL site and does not use public roads or transportation routes (Ref. 3-7).

Once received, the spent fuel moves through the facility via the Transfer Tunnel on either the cask or canister trolley. The cask trolley receives the transfer cask and transports it on rails from the Cask Receipt Area into the Transfer Tunnel to the FPA cask port. It also returns the empty transfer cask to the Cask Receipt Area. The canister trolley delivers an empty canister and basket assembly to the FPA from the CCA. It then receives the loaded basket assembly at the FPA canister port, delivers it to the CCA, and delivers the sealed canister to the Storage Area load/unload port where it is retrieved by the CHM. The canister trolley includes a shielded cask and jacking system that allows it to be elevated into the appropriate ports and limits radiation streaming in the Transfer Tunnel.

3.1.2.3 Onsite Generated Waste

Both liquid and solid waste are generated as part of spent fuel storage operations. Solid waste consists of primary waste (DOE fuel canisters, miscellaneous container waste, etc.) and process-generated waste such as paper, rubber, plastic, rags, machinery parts, tools, vacuum cleaner debris, welding materials, and high-efficiency particulate air (HEPA) filters. The waste is compacted as appropriate and packaged for offsite disposal at the INEEL Radiological Waste Management Complex (RWMC). No long-term storage of solid waste occurs within the facility.

The liquid waste results from decontamination activities in the Transfer Tunnel, CCA, workshop, and Solid Waste Processing Area. A personnel safety shower in the Operations Area may also generate liquid waste. A mobile treatment service contractor treats the liquid waste if required and transports it as low specific activity waste for offsite disposal.

More detailed discussions of solid and liquid waste handling are found in Sections 3.3.7.2 and 3.3.7.3, and Chapter 6.

3.1.2.4 Utilities

The ISF Facility interfaces with INEEL for utilities necessary to operate this facility. Site utilities consist of:

- electrical power
- potable water
- sanitary waste
- fire water
- communications

All of the utilities described below are classified not important to safety (NITS). Consequently, the sharing of these utilities does not increase the probability or consequences of an accident or malfunction of structures, systems, or components that are important to safety.

3.1.2.4.1 Electrical Power

Electrical power is supplied to the ISF site at 13.8 kV with up to 5000 kVA available from the local power utility. A unit substation with a step-down transformer is provided to distribute power at 480 V to satisfy the power requirements of this facility. A diesel generator provides facility standby power requirements. An uninterruptible power supply (UPS) provides power to specific electrical components as an alternate power source following a loss of power event.

3.1.2.4.2 Potable Water

Existing INTEC site utilities supply potable water to the ISF site for drinking and other domestic needs within the ISF Facility. The potable water system meets the anticipated demand for service and support facilities of the ISF, administrative offices, and security building. The system also provides makeup water for heating, ventilation, and air conditioning (HVAC) chilled-water equipment.

3.1.2.4.3 Sanitary Wastewater System

INTEC supplies a sanitary wastewater tie-in to the ISF site to provide floor and end-device (toilets, sinks, etc.) drains throughout the facility. Only floor drains from uncontaminated areas drain to the sanitary sewer. The sanitary wastewater tie is connected to the existing INTEC site sewer system.

3.1.2.4.4 Fire Water System

INTEC provides fire suppression water to hydrants, standpipes, and sprinklers in the ISF Facility through two lines separate from the domestic water supply. The system contains sectional control valves to ensure that distribution piping can continue to provide flow during a single component failure.

3.1.2.4.5 Communications

The communications and alarm system provides the ISF site with fire detection, alarm capability, and internal and external communications. The fire detection and alarm system detects fires within the facility and provides supervisory warnings, trouble signals, and alarms to the INEEL Central Fire Alarm Station.

The ISF site receives fire brigade response from INEEL. A fire alarm status panel assists the fire brigade in locating the fire. The communication system provides the ISF Facility with voice, data, and personnel paging. This system connects to the existing INTEC broadband local area network.

Rather than having a single control room, the ISF Facility employs discrete control areas for the supervision of activities within those areas. Examples of control areas include the Cask Receipt Area, Operating Gallery, Canister Closure Area, and Storage Area. The design of all control areas incorporates features (accessibility, shielding, lighting, ventilation, communication, etc.) needed to support normal operations and to provide safe control of the facility under off-normal or accident conditions.

3.2 STRUCTURAL AND MECHANICAL SAFETY CRITERIA

3.2.1 Tornado and Wind Loadings

3.2.1.1 Applicable Design Parameters

3.2.1.1.1 Design Basis Wind

The design basis wind is taken from American Society of Civil Engineering (ASCE) Standard ASCE-7 for the facility location and is based on an annual probability of exceedance of 0.02 (50-year return period) (Ref. 3-8). The velocity pressure equation in Section 3.2.1.2.1 below applies an importance factor of 1.15 that yields a resulting value equivalent to the 100-year return period. The following parameters are established for the design basis wind:

- Wind Velocity: 90 mph (3-second gust at 33 feet above ground) - Exposure Category: C

Meteorological monitoring is performed at various locations on the INEEL site and is described in Chapter 2.

3.2.1.1.2 Design Basis Tornado

The design basis tornado characteristics are specified in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.76 for Region III, and as modified by NUREG/CR-4461 and SECY-93-087 as follows (Refs. 3-9, 3-10, and 3-11):

Maximum wind speed	200 mph
Rotational speed	160 mph
Maximum translational speed	40 mph
Minimum translational speed	5 mph
Radius of maximum rotational speed	150 feet
Pressure drop	1.5 psi
Rate of pressure drop	0.6 psi/sec

The design basis tornado missiles are taken as Spectrum II missiles in Region III as identified in Section 3.5.1.4 of NUREG-0800 and are presented in Table 3.2-1 (Ref. 3-12). Tornado missiles used in the analysis of the ISF Facility are discussed further in Section 3.2.1.4.

3.2.1.2 Determination of Forces on Structures

3.2.1.2.1 Design Basis Wind

The design basis wind is converted to velocity pressure based on ASCE 7 using the following formula:

$$q_z = 0.00256\, K_z\, K_{zt}\, K_D I\, V^2$$

In which
q_z = Velocity pressure in psf
K_z = Exposure coefficients = 1.17 (Table 6-3 of ASCE 7)
K_{zt} = Topographic factor = 1.0
K_D = Wind directionality = 1.0
I = Importance factor = 1.15 (Table 6-2 of ASCE 7 for Category III Buildings)
V = Design basis wind velocity = 90 mph

The gust factors and building pressure coefficients are in accordance with ASCE 7. The manner in which the design basis wind load is combined with other applicable design loads is given in Section 3.2.5, *Combined Load Criteria*.

3.2.1.2.2 Design Basis Tornado

The design basis tornado wind is converted to effective velocity pressure using the following formula:

$$q = 0.00256\,V^2$$

In which q = velocity pressure in psf
V = tornado wind velocity in mph.

The velocity pressure is assumed constant with height and gust factors taken as unity. Building pressure coefficients are in accordance with ANSI A58.1.

The manner in which the total tornado load is combined with other applicable loads is given in Section 3.2.5, *Combined Load Criteria*. The method of combining the three individual tornado-generated effects (wind load, differential pressure load, and missile load) is based on Section 3.3.2 of NUREG-0800 as presented in the following (Ref. 3-12):

i. $W_t = W_w$
ii. $W_t = W_p$
iii. $W_t = W_m$
iv. $W_t = W_w + 0.5W_p$
v. $W_t = W_w + W_m$
vi. $W_t = W_w + 0.5\,W_p + W_m$

In which W_t = total tornado load
W_w = tornado wind load
W_p = tornado differential pressure = 1.5 psi
W_m = tornado missile load

3.2.1.3 Ability of Structures to Perform Despite Failure of Structures not Designed for Tornado Loads

Structures that are considered NITS, but that could potentially compromise the integrity of structures important to safety (ITS) upon failure, are designed to the same wind design loads and load combinations, as the ITS structures.

Structures designated NITS with the same wind and tornado missile design loads as ITS structures are:

- Cask Receipt Area primary structural steel framing other than that forming the central load path for the crane loads
- Storage Area primary structural steel framing
- Operations Area/gallery primary structural steel framing surrounding the Transfer Area

Metal siding and roof deck for steel structures are allowed to fail under tornado loads; however, the structural framing is designed to withstand the full tornado wind pressure load transferred from the metal siding and roof decks.

3.2.1.4 Tornado Missiles

The design basis tornado for the ISF Facility site is consistent with NRC Regulatory Guide 1.76 and NUREG 0800, Section 3.5.1.4, Region III, as modified by NUREG/CR-4461 and SECY-93-087 (Refs. 3-12, 3-10, and 3-11). Based on the maximum wind speed established by these guidelines (200 mph), larger tornado missiles are not considered credible for the ISF Facility. Smaller Spectrum II tornado missiles, such as the 6-inch diameter schedule 40 pipe, the 1-inch diameter steel rod, and the wood plank are incorporated in the tornado missile analysis.

The mass, dimensions, and velocity for the design basis tornado missiles are presented in Table 3.2-1. The effects of missile impact are evaluated in terms of local damage such as penetration, perforation, scabbing, and overall structural response (i.e., bending and shearing in the target structure that absorbs the impact energy).

Individual ITS structures, systems, and components (SSCs) within the ISF Facility are designed or protected to withstand the direct effects of tornado winds, pressures, and the Spectrum II tornado missiles identified above, as appropriate. Chapter 4 provides design details related to tornado protection for individual SSCs. For some SSCs, such as the CHM and the cask receipt hoist, tornado-related design features are not addressed because the probability of tornado occurrence while these components are handling SNF is too low to be credible. Chapter 8 describes the determination of these probabilities. Appropriate administrative controls and operating limitations restrict fuel handling activities when tornado watches or warnings are in effect.

Resistance to local failure or perforation of steel elements is determined by use of the Ballistic Research Laboratory (BRL) Equation. For concrete, the local effects are evaluated by utilizing the Bechtel Formula (Ref. 3-13).

The overall structural response is evaluated using conservation of momentum and energy techniques to calculate transmitted kinetic energy to the target structure and to determine the energy absorption capabilities of affected structural elements using allowable ductility limits. The methodology presented in *Topical Report, Design of Structures for Missile Impact,* has been used in the evaluation (Ref. 3-13).

For steel targets, the plate thickness that corresponds to threshold of perforation is given by the BRL formula as:

$$T = \frac{(0.5MV_s^{\,2})^{2/3}}{672D}\text{, where}$$

T = Steel plate thickness in inches to just perforate
M = Missile mass in $lb\text{-}sec^2/ft$
V_s = Striking missile velocity normal to the target surface in ft/sec
D = Missile diameter in inches

The steel barrier thickness required to prevent perforation is taken as 1.25T.

For concrete targets, the concrete thickness required to resist scabbing is given by the Bechtel Formula as

$$s = \frac{15.5W^{0.4}V_o^{\ 0.5}}{\sqrt{f_c'}D^{0.2}} \text{(Solid Steel Missile)}$$

$$s = \frac{5.42W^{0.4}V_o^{\ 0.65}}{\sqrt{f_c'}D^{0.2}} \text{(Solid Pipe Missile)}$$

where s = scabbing thickness in inches
W = missile weight in pounds
V_0 = missile velocity in ft/sec
D = nominal missile diameter in inches
f_c' = concrete compressive strength in psi

For design use, the calculated thickness is increased by 20 percent.

Based on the techniques described above, the analysis of tornado missile impact effects determined the controlling credible missile for local effects to be a 6-inch, schedule 40 steel pipe driven by the postulated tornado at 33 ft/sec. The minimum steel thickness required to resist penetration by this missile is 0.08 inches. The minimum concrete thickness required to resist scabbing is 6.8 inches. The ITS structural components of the ISF Facility exceed these dimensions.

For evaluating concrete walls up to 30 feet above ground for overall effects of tornado missiles, Spectrum II Missile D (utility pole) is judged to be the most conservative missile based on the kinetic energy per unit area. Although the utility pole is not considered a credible missile for the ISF Facility due to the relatively low wind speeds associated with the design basis tornado, the overall effects of a utility pole impact were evaluated for ISF Facility reinforced concrete structures to provide an added degree of conservatism in the analysis. The utility pole is considered a soft missile characterized by significant local deformation of the missile. The procedures for evaluating the overall effects are outlined below (Ref. 3-13):

- Calculate an applied force-time history assuming a rectangular impulse.
- Determine reinforced-concrete section properties using an average moment of inertia of cracked and uncracked sections, the spring constant of the wall panel, and the effective mass of the wall panel assuming a circular fan failure.
- Determine the ductility of the wall panel by calculating the period of the structure and the maximum resistance of the wall panel. Compare the calculated ductility of the wall panel with the allowable ductility to ensure that a sufficient margin exists.

The evaluation concluded that a 24-inch thick reinforced concrete wall, minimally reinforced, is sufficient to withstand the impact of the utility pole missile.

3.2.2 Water Level (Flood) Design

3.2.2.1 Flood Elevations

The ISF Facility design is based on the probable maximum flood event described in Section 2.4.3. Flood elevations have been converted to the 1988 North American Vertical Datum (NAVD 88) survey, which is used for the design of the ISF Facility. In the remaining part of this section the probable maximum flood (PMF) level is defined as 4920.71 feet msl (NAVD 88).

The floor elevations of the ISF Facility are below the PMF flood elevation. For example, the floor of the Cask Receipt Area is at elevation 4913 feet, 2 inches; the floor of the Transfer Tunnel is at elevation 4912 feet, 6 inches; the floors of the FPA and Solid Waste Processing Area are at elevation 4917 feet, 6 inches; and the floor of the Liquid Radioactive Waste Storage Tank Area is at elevation 4915 feet. The facility's administrative requirements and design, however, prevent the exposure of SNF to flood waters.

A flood elevation of approximately 4921 feet msl is used in the design of each structure for buoyancy and static water force effects.

3.2.2.2 Phenomena Considered in Design Load Calculations

As described in Section 2.4.3, the wind activity at the INEEL site coincident with the largest projected flood crest could not produce waves that would exceed 0.5 foot due primarily to the shallow depth of water surrounding most INTEC buildings (Ref. 3-14). Thus, the static and dynamic effects of wave activity would be negligible.

As described in Sections 2.4.5 and 2.4.6, tsunami, surge, and seiche flooding are not potential natural phenomena.

As described in Section 2.4.4, the leading edge of the flood water reaches the INTEC site in about 16 hours. Average water velocities on the INEEL site are 1 to 3 feet/sec.

The design load calculations treat the floodwater as a hydrostatic force.

3.2.2.3 Flood Force Application

The forces and other effects resulting from flood loadings are applied to those SSCs below elevation 4921 feet msl (NAVD 88) that are not protected from floodwater by flood protection measures.

The buoyancy and static water force effects are considered. The probable maximum flood is a low velocity event and therefore, hydrodynamic forces on the structures are negligible.

3.2.2.4 Flood Protection

When the transfer cask is loaded onto the cask trolley, the cask bottom is at elevation 4920.5 feet msl, only slightly below the 4921 feet of the PMF. Therefore, buoyant forces are not a concern. The top of the cask remains well above the PMF elevation. The DOE Transfer Cask has been designed to withstand pressures of 100 psi; the bottom lid of the cask is fitted with pressure-retaining o-ring gaskets, and securely torqued to the cask body. Therefore, it is highly unlikely that water will enter the DOE Transfer Cask. Appendix A to the SAR provides more details regarding the DOE Transfer Cask.

Measures to protect the FPA and the storage vault from flooding include the sealing of construction joints below the PMF elevation to ensure water tightness.

The ISF canister is set inside a canister cask on the canister trolley. The canister cask is watertight on its external surfaces. The open top of the canister cask is above the PMF elevation. Hence, the canister cask provides flood protection for the ISF canister when it is in the Transfer Tunnel.

3.2.3 Seismic Design

The ISF Facility is designed to withstand the effects of natural phenomena, including earthquakes, in accordance with 10 CFR 72.102 and 10 CFR 72.122 (Ref. 3-1). Seismic monitoring is performed at several locations on the INEEL site and is described in Chapter 2. 10 CFR Part 72 requires that design ground motions be developed in accordance with 10 CFR 100, Appendix A, which is primarily based on a deterministic methodology (Ref. 3-15). The current NRC geologic and seismic siting criteria for licensing nuclear power plants (10 CFR 100.23) identify a probabilistic seismic hazard analysis (PSHA) as a means to determine the design earthquake and account for uncertainties in the seismological and geological evaluations. The design ground motions developed for the ISF Facility are based on a PSHA. This approach is also consistent with NRC-approved TMI-2 ISFSI design, and the DOE approved revision to design earthquake parameters for the INEEL site.

3.2.3.1 Input Criteria

The control motions from which the design earthquake parameters for the ISF site were developed are specified at the top of basalt rock at 25 ft to 27.5 feet below ground surface. They are based on a probabilistic seismic hazard evaluation for the INTEC site, as discussed in Sections 2.6.2.4 through 2.6.2.6. The horizontal rock design response spectra were first developed by incorporating smoothed, broadened regions of the peak accelerations, velocities, and displacements defined by the 2500-year return period rock uniform hazard spectra (UHS). Two statistically independent horizontal rock design time histories were developed from the rock design response spectra in conformance with the enveloping criteria of NUREG-0800 (Ref. 3-12).

Using the horizontal rock design time histories as input, site-specific soil response analyses were performed to obtain the mean ground motion hazard level and design earthquake ground motion, as discussed in Sections 2.6.2.4 through 2.6.2.6. To account for the variations in soil properties, three free-field ground time histories that correspond to the mean minus one, the mean, and the mean plus one standard deviation strain-iterated soil profiles were generated for each of the two horizontal and the vertical directions. These free-field ground time histories were used as input motions to the soil-structure interaction analysis discussed in Section 3.2.3.1.8.

3.2.3.1.1 Design Response Spectra

The site specific free-field ground response spectra are represented by three unsmoothed response spectra generated from the three corresponding ground design time histories in each of the three orthogonal directions, as discussed in Sections 2.6.2.4 through 2.6.2.6. The three response spectra in each of the two horizontal directions and one vertical direction for 5-percent damping are compared with the Regulatory Guide 1.60 design response spectra anchored at their respective peak ground accelerations (PGAs), as shown in Figure 3.2-1, Figure 3.2-2, and Figure 3.2-3 (Ref. 3-16). The ground response spectra are derived from the site-specific UHS and therefore, deviation in general spectral shapes from the Regulatory Guide 1.60 design response spectra is apparent. The higher spectral values in the high frequency range are due to amplification of the accelerations in this region of the spectra by the shallow soil at the ISF site.

3.2.3.1.2 Design Response Spectra Derivation

The horizontal rock design response spectra, which constitute the control motions for the ISF site, are derived from the site-specific UHS, as discussed in Sections 2.6.2.4 through 2.6.2.6. The free-field ground response spectra are generated from the free-field ground time histories for comparison with the Regulatory Guide 1.60 design response spectra, as discussed in Section 3.2.3.1.1.

3.2.3.1.3 Design Time History

The horizontal rock design time histories were developed from the horizontal rock design response spectra in accordance with the enveloping criteria of NUREG-0800 (Ref. 3-12), as discussed in Sections 2.6.2.4 through 2.6.2.6. The free-field ground time histories were derived from the site-specific soil response analysis using the horizontal rock design time histories as input, as discussed in Sections 2.6.2.4 through 2.6.2.6.

3.2.3.1.4 Use of Equivalent Static Loads

The seismic response of most major components is calculated using the response spectrum method. However, some components, such as the cask and canister trolleys, are designed by the equivalent static method. To obtain the equivalent static loads on the equipment, the peak acceleration of the floor response spectra in north-south, east-west, and vertical directions at the appropriate locations within the building are multiplied by a factor of 1.5. Appropriate damping values (Table 3.2-2) are incorporated into the analysis.

3.2.3.1.5 Critical Damping Values

The percentage of critical damping values used in the analysis of SSCs ITS are in accordance with NRC Regulatory Guide 1.61 as shown in Table 3.2-2 (Ref. 3-17). Damping values used in the analysis of ISF SSCs are detailed in Section 4.7.3.3.

3.2.3.1.6 Bases for Site-Dependent Analysis

A site-dependent analysis was performed to develop design response spectra and design time-histories for seismic design of SSCs ITS. The design response spectra and design time-histories are defined at the site bedrock outcrop based on the site-specific probabilistic seismic hazard analysis conducted for the INTEC area at INEEL (Ref. 3-18). Site-specific soil properties were used as input for the site-dependent analysis.

The bases for the site-dependent analyses are described in Sections 2.6.2.5 and 2.6.2.6.

3.2.3.1.7 Soil-Supported Structures

All ITS structures and other facility structures are supported by soil. The average soil depth within the immediate vicinity of the buildings is approximately 27 feet. As described in Section 2.6.4.8, liquefaction is not a concern at the ISF Facility site.

3.2.3.1.8 Soil-Structure Interaction

SSI Model Development

This analysis of the ISF Facility ITS structures for soil-structure interaction (SSI) consisted of the following activities:

- A model of the site soil was developed based on the strain-compatible soil properties
- Models of the Transfer Area, Fuel Storage Area, and Cask Receipt Area structures were developed.
- Seismic analyses of the Transfer Area, Fuel Storage Area, and Cask Receipt Area structures accounting for SSI effects were performed
- In-structure response spectra (ISRS) and other seismic response quantities were generated.

SASSI Computer Program

The effects of soil-structure interaction (SSI) on the seismic response of the three main ISF facility structures was analyzed using the computer program SASSI (Ref. 3-19). This program uses the flexible volume method to model soil-structure systems.

In the flexible volume method, the complex soil-structure system is partitioned into two substructures; i.e., the structure and the soil. In this partitioning, the structure consists of the aboveground structure, plus the subgrade, minus the excavated soil. The structure (aboveground structure, subgrade, and excavated soil) is modeled by finite elements. The soil substructure is modeled as a continuum consisting of infinite horizontal soil layers overlying a homogeneous half space.

The input motion for seismic analysis using SASSI consists of three simultaneous ground motion acceleration time-histories, one in each of the three orthogonal directions, at a user-specified control point. To calculate the seismic response of the structure, SASSI first generates transfer functions at selected frequencies. These transfer functions multiplied by the Fourier transform of the input motion result in the Fourier transforms of the response. The time-histories of the seismic response are then calculated as the inverse of the Fourier transforms of the response.

Soil Model Development

Soil properties for three soil profile stiffness cases were used to develop of the soil models for input to SASSI. Use of these three soil stiffness cases satisfies NUREG-0800 Section 3.7.2, Subsection II.4 requirements for consideration of uncertainties in soil properties.

One SASSI soil model was developed for each of the three soil stiffness cases considered in the seismic analysis. Each model consisted of 24.5 feet of soil overlaying a homogeneous rock half space. In the SASSI soil models, the relatively soft 2.5 foot thick soil layer at the surface was neglected since the structure foundations are below this layer.

In the SASSI soil models, soil layers at depths below 2.5 feet and their corresponding material properties were defined as identified in the site response analysis. Modeling of the homogeneous rock half-space was based on site specific properties for depths of 27 feet below the soil surface. The soil layer thicknesses were defined at increments of three feet or less. With these layer thicknesses, the SASSI soil models are capable of transmitting frequencies in excess of 50 Hz.

Structural Model Development

Structural models for the seismic analysis were developed primarily from the fixed-base finite element models used for general analysis of the ISF structures. These models were developed using the finite element program SAP2000. Nodes were typically permitted to have six degrees of freedom each, three translations and three rotations. The concrete base mats, floor slabs, and walls were typically modeled by two-dimensional plate/shell elements. Gross concrete thicknesses were typically assigned to these plate elements. The structural steel columns, beams, and braces were represented by one-dimensional frame elements.

Heavy equipment components, such as the Canister Handling Machine in the Storage Area, were explicitly modeled to account for their impact on the overall soil-structure system response. Heavy equipment components whose positions can vary were located in the models to maximize overall structure seismic response. Lumped masses were included to represent other weights supported by the structure.

For the SSI seismic analysis, structural models in SASSI were developed by transforming the SAP2000 models. Model modifications typically consisted of:

- Revising node locations in the SASSI structural model to eliminate the constraint equations in the SAP 2000 model
- Re-meshing the base mat and walls to reduce the number of interaction nodes in the SASSI model
- Modeling the excavated soil by brick elements in SASSI.

Damping values assigned to the structures were based on values specified by Regulatory Guide 1.61 for seismic analysis against the Safe Shutdown Earthquake (SSE). Response of the Transfer Area and Storage Area structures is not particularly sensitive to the structure damping value assigned. The results of the SSI analysis demonstrated that much of the flexibility in the soil-structure systems for these areas is attributed to the soil. In such cases, soil material and radiation damping typically dominate overall energy dissipation of the soil-structure system.

Seven percent of critical damping was assigned to the Transfer Area and Storage Area structures, whose seismic load-resisting systems are comprised primarily of reinforced concrete. Four percent of critical damping was assigned to the Cask Receipt Area structure. The seismic load-resisting system for the Cask Receipt Area consists of both steel moment-resisting frames with welded connections and steel braced frames with bolted connections. The structure damping assigned to the Cask Receipt Area uses the value specified for welded steel structures by Regulatory Guide 1.61.

Simplified Stick Models

Simplified stick models were also developed to account for potential structure-to-structure interaction effects in the SSI analysis. Dynamic properties of the stick model duplicate the fundamental modes of the fixed base finite element models as follows:

- One lumped mass was located at the elevation of the flexible mass centroid calculated by the SAP2000 model. The magnitude of the lumped mass was based on the effective mass participating in the fundamental horizontal modes calculated by the SAP2000 eigen solution
- One lumped mass was located at the base mat. The magnitude of this mass was taken to be the difference between the total structure mass and the effective mass lumped at the upper node as described above. The total structure mass moments of inertia were also assigned at the base mat.
- The base mat was modeled by plate elements having very high stiffnesses to simulate an assumed rigid foundation.

Seismic Response Analysis

Input to the SASSI analyses consisted of:

- Free-field earthquake acceleration time-histories,
- Soil models,
- Structure models.

Separate analyses were performed for the Transfer Area, Storage Area, and Cask Receipt Area structures. The detailed finite element model for the structure being analyzed was used. To account for potential structure-to-structure interaction effects due to coupling by the soil, the simplified stick model for the adjacent structure was included. For example, the SASSI model used for analysis of the Transfer Area structure included the simplified stick model for the adjacent Storage Area structure. Inclusion of the stick model of the adjacent structure is considered to be sufficient to capture the effect of its overall soil-structure system response on the structure of interest. Use of the detailed finite element model of both structures was not computationally practical. Figure 3.2-4, Figure 3.2-5, and Figure 3.2-6 show the SSI models for the three ITS structures.

Each structure was analyzed for each of the three soil stiffness cases (best estimate, lower bound, and upper bound). The use of the three soil stiffness cases accounts for uncertainties in soil properties as required by NUREG-0800 Section 3.7.2, Subsection II.4. The same soil models for each of the soil stiffness cases were applicable to each structure analyzed. Excitation input to the analysis of a particular soil stiffness case consisted of the free-field earthquake acceleration time histories corresponding to that soil case. The control point for these input time-histories was specified to be at the soil surface consistent with the site response analysis. The three orthogonal earthquake acceleration time histories (two horizontal components and the vertical component) were input to the analysis simultaneously. Simultaneous input is acceptable since the NUREG-0800 Section 3.7.2, Subsection II.6.b requirement on statistical independence of the three orthogonal acceleration time-histories was satisfied

Results from the SASSI analysis consisted of transfer functions and in-structure acceleration time-histories. The in-structure accelerations were post-processed by other software to obtain in-structure response spectra and relative structure displacements.

Transfer Functions

Transfer functions are intermediate results produced by SASSI, which account for the dynamic characteristics of the structure and the soil. The transfer function is defined as the ratio of the Fourier transform of the response at a node within the SASSI model to the Fourier transform of the input.

A large number of transfer functions are required for a typical SSI analysis. To reduce the computational effort, SASSI explicitly calculates the transfer functions for the nodes of interest at a limited number of frequencies specified by the user. SASSI then calculates the transfer functions for a node by interpolating between the values that were explicitly calculated.

In-Response Spectra

In-structure acceleration time-histories were calculated for selected nodes where structure seismic responses are required for structure design and equipment seismic qualification. The acceleration time-histories were post-processed to obtain in-structure acceleration response spectra (ISRS).

ISRS at 2%, 4%, 5%, and 7% of critical damping were calculated at the selected nodes in accordance with NUREG-0800 Section 3.7.2, Subsections II.5.b and II.9 and Regulatory Guide 1.122. Frequency intervals for calculation of the ISRS were equal to or less than the suggested values in Table 1 of Regulatory Guide 1.122. ISRS at a given node for the three soil stiffness cases were enveloped. The enveloped ISRS were then broadened by ±15% on frequency to account for modeling and analysis uncertainties following Regulatory Guide 1.122

The design ISRS for individual structures and equipment were developed by enveloping the nodal enveloped and broadened response spectra over a sufficient number of nodes to account for the in-structure response in specific areas in the buildings. For example, the design response spectra for the Fuel Handling Machine (FHM) are developed by enveloping the broadened response spectra for nine locations along the entire length of both north and south crane rails. The same methodology was used to develop the response spectra at the base of the individual building structures that were used as input to their analyses. The in-structure design response spectra for the ISF Facility are shown in Figure 3.2-11 through Figure 3.2-52.

Summary of SSI Results

The seismic load-resisting systems of the Transfer Area and Storage Area structures are both composed of stiff concrete shear walls and floor/roof diaphragms. Soil flexibility has significant effect on the frequencies of these structures. Peak accelerations at the first floors of the two structures in all three directions approximately equal or slightly exceed the free-field peak ground accelerations (PGA) at the soil surface. Increases in peak accelerations through the heights of the structures are typically modest.

The seismic load-resisting system of the Cask Receipt Area is composed of structural steel moment and braced frames. This structure is more flexible than the Transfer and Storage Area structures, and consequently exhibits different seismic behavior. Soil-structure interaction typically has relatively little effect on the seismic response of the Cask Receipt Area. Peak horizontal accelerations near the top of the structure exhibit significant amplification above the free-field peak ground acceleration at the soil surface.

Peak vertical accelerations at and below the low roof exhibit little amplification because of the structure's vertical stiffness.

3.2.3.2 Seismic System Analysis

3.2.3.2.1 Seismic Analysis Methods

Seismic analysis of SSCs ITS is performed using a response spectrum method of dynamic analysis except as noted in Section 3.2.3.1.4, *Use of Equivalent Static Loads*. Input to the seismic analysis of SSCs are the acceleration response spectra generated from the SSI seismic response analysis discussed in Section 3.2.3.1.8. The response spectra for various locations within the facility are provided in Figures 3.2-11 through 3.2-52.

Seismic Analysis of Structures

A response spectrum method is utilized for the seismic analysis of the Cask Receipt Area, Transfer Area, and Storage Area structures. Each area structure is modeled as a three-dimensional finite element model with fixed base. The SAP2000 finite element analysis program is used for the analysis of reinforced concrete structures and the STAAD/PRO computer program is used for the analysis of the Cask Receipt Area (Refs. 3-20 and 3-21).

The Cask Receipt Area, a framed-steel structure, is modeled using a series of interconnected three-dimensional beam elements. Only the central portion of the steel structure and individual column foundations that form the load path of the cask receipt hoist are considered ITS. The remaining interconnected steel structure is modeled primarily to account for the effects of seismic interaction. The mass and stiffness characteristics of the cask receipt hoist and support frame are also modeled with the supporting steel structure. The model of the Cask Receipt Area is shown in Figure 3.2-7.

The Transfer Area consists of reinforced-concrete cells including a segment of the Transfer Tunnel supported on a foundation mat and the surrounding interconnected structures of steel-frame construction. The reinforced-concrete members are modeled as three-dimensional shell elements and the structural-steel members are modeled as three-dimensional frame elements. Only the reinforced-concrete structure is considered ITS. The steel structure is modeled primarily to obtain the effects of seismic interaction. The mass and stiffness characteristics of the FHM are also incorporated in the Transfer Area mathematical model. The model of the Transfer Area is shown in Figure 3.2-8 and Figure 3.2-9.

The Storage Area consists of reinforced-concrete vaults, a segment of the Transfer Tunnel on a common foundation mat, and an overhead steel-frame structure supported on the exterior concrete walls. The reinforced-concrete members are modeled as three-dimensional shell elements except at the top of the storage vaults where the concrete slabs with holes for the tube assemblies are modeled as a series of interconnected three-dimensional frame elements. The tube assemblies are modeled with pinned-base connection and lateral support at the top. The steel-framed structure is modeled as a three-dimensional frame element primarily to obtain the effects of seismic interaction. The mass and stiffness characteristics of the CHM including the trolley and bridge structure are also incorporated in the Storage Area mathematical model. The model of Storage Area is shown in Figure 3.2-10.

The response spectrum method of dynamic analysis is performed separately for each of the three area mathematical models because they are seismically isolated from each other by an isolation joint. The response spectra generated from the SSI analysis described in Section 3.2.3.1.8 at the foundation level of respective SSI models are applied at the fixed base of the corresponding area mathematical models as seismic input (see Section 3.2.3.2.4, *Rocking and Translational Response Summary*).

The General Modal Combination technique was used to combine modal results as presented in ASCE-4 (Ref. 3-50). The square root of the sum of the squares was used to combine spatial components based on the guidelines of NRC Regulatory Guide 1.92 (Ref. 3-22).

Seismic Analysis of Systems and Components

Specific seismic design features of each of the SSCs listed below are discussed in Chapter 4.

Cask Receipt Crane

The cask receipt crane is a stationary lifting device consisting of two main girders, two equalizer end support beams, an equalizer beam, two drums, and hoist ropes. The model for seismic analysis is represented by a general three-dimensional lumped mass system interconnected by weightless elastic members. The model's geometry reflects the overall size, length, connectivity, and stiffness of various structural members.

A linear elastic response spectrum method of seismic analysis is performed utilizing STAAD PRO, a general-purpose finite element program available in the public domain. The design response spectra are used as input in the north-south, east-west, and vertical directions respectively. The spatial components are combined in accordance with NRC Regulatory Guide 1.92.

The modes are divided into flexible and rigid ranges. Modes in the flexible range are combined by the square root of the sum of the square method while modes in the rigid range, which accounts for missing masses, are combined by the algebraic sum method. The responses from the two ranges are further combined by the square root of the sum of the square method, which is equivalent to taking into account all modes and is consistent with Section 3.7.2 of NUREG-0800 (Ref. 3-12). In lieu of a 7-percent damping applicable to this system, a conservative 5-percent modal damping is used in the analysis.

Cask Trolley

The cask trolley is a welded steel frame consisting of vertical, horizontal, and bracing members supported on a truck trolley and is equipped with seismic restraints and a locking pin. An equivalent static method is used for seismic analysis. Equivalent static loads are obtained by increasing the trolley mass by a factor of 1.5 and applying it to the peak acceleration of the design response spectra with 4-percent damping. Three separate static seismic analyses are performed for two horizontal directions and one vertical direction using RISA 3D computer program (Ref. 3-23). The spatial components are combined by the square root of the sum of the squares method in accordance with NRC Regulatory Guide 1.92 (Ref. 3-22).

Canister Trolley

The canister trolley is also a welded steel frame supported on a truck trolley equipped with seismic restraints and a locking pin. The method of seismic analysis is similar to that for the cask trolley.

Fuel Handling Machine

The FHM is a bridge crane consisting of bridge beams, bridge end trucks, and a trolley structure with bolted connections. The FHM, including the runway support beams, is represented by a finite element model consisting of generalized three-dimensional beam, plate, and mass elements.

A response spectrum method of seismic analysis is performed in the three orthogonal directions. The design response spectra in the respective directions are used as seismic input. A damping value of 7 percent is used for the bolted FHM structure in accordance with NRC Regulatory Guide 1.61 (Ref. 3-17). The number of modes considered in the analysis is based on the criterion that inclusion of additional modes does not result in more than a 10 percent increase in responses. The method of combining the modal responses and spatial components is in accordance with NRC Regulatory Guide 1.92.

Canister Handling Machine

The CHM consists of a bridge assembly including girders, end trucks, and seismic restraints; a trolley assembly with structural steel frame, cross travel drive unit, and seismic restraints; and a cask/turret assembly mounted with a hoist and grapple system.

A linear elastic response spectrum method of seismic analysis is employed using the general-purpose finite element program ANSYS (Ref. 3-24). The design response spectra at the CHM runway level in three orthogonal directions are used as the seismic input. A damping value of 7 percent is used in the seismic analysis. The method of combining the modal responses and spatial components is in accordance with NRC Regulatory Guide 1.92 (Ref. 3-22).

Storage Tube Assembly

Two sizes of storage tube assembly are utilized to accept either 18- or 24-inch outside diameter ISF canisters. A radial gap exists between the canister and inside wall of the storage tube. A similar gap also exists between the inside wall of the canister and canister internals. The storage tube is laterally supported at the bottom and by the charge face and is free standing on a support stool. The canister is free standing inside the storage tube.

With the gaps present, the canister and storage tube system is mathematically a nonlinear system; therefore, a response spectrum method of analysis is inappropriate. The seismic analysis is, therefore, performed using the equivalent static method and conservative seismic accelerations. A modal analysis is performed on the half-model of the canister and storage tube assembly using ANSYS.

The lateral fundamental frequency of the system is less than 1 Hz and the vertical frequency is greater than 100 Hz. To obtain the lateral design acceleration, the peak spectral accelerations in the north-south and east-west directions are first combined by the square root of the sum of the square method and amplified by a factor of 1.5. The result is further multiplied by a factor of 1.1 for additional conservatism.

The design vertical acceleration is obtained by multiplying the zero period acceleration by a factor of 1.1. The design response spectra at the charge face level and at the storage vault floor level for 4-percent damping are used in determining the lateral and vertical accelerations for design.

3.2.3.2.2 Natural Frequencies and Response Loads

The natural or fundamental frequencies of vibration were calculated as part of the response spectra analysis for the three main building structures and major equipment. Section 4.7.3.3 presents these and shows plots of significant modes of vibration.

3.2.3.2.3 Procedures Used to Lump Masses

The three primary facility structures (Cask Receipt Area, Transfer Area, and Storage Area) are each modeled using three-dimensional finite elements as described in Section 4.7.3.3.

For large equipment and related supports including the Cask Receipt Area crane, FHM, and CHM, the mass, stiffness, and damping characteristics are explicitly modeled and incorporated into the building structural models.

3.2.3.2.4 Rocking and Translational Response Summary

Rocking is explicitly addressed in the SSI analysis described in Section 3.2.3.1.8. Rocking and torsional effects are not explicitly captured in the fixed-base finite element seismic-system analysis of the buildings. The input motions for the three areas considers these effects by enveloping the in-structure response spectra from the SSI analysis across the entire base of the structures. The in-structure accelerations calculated from the fixed-base analysis are then compared to those calculated from the SSI analysis to evaluate the structural response.

3.2.3.2.5 Method Used to Couple Soil with Seismic-System Structures

The method used to couple soil with the seismic-system structures is provided in Section 3.2.3.1.8, *Soil-Structure Interaction.*

3.2.3.2.6 Method Used to Account for Torsional Effects

Torsional effects are captured by using three-dimensional models of the structures. The three-dimensional model captures responses in all six degrees of freedom for each direction of seismic motion.

3.2.3.2.7 Methods for Seismic Analysis of Dams

The ISF Facility does not include dams.

3.2.3.2.8 Method to Determine Overturning Moments

The overturning moments for the area structures (Cask Receipt Area, Transfer Area, and Storage Area) are determined by algebraically combining the overturning moment caused by the horizontal inertia forces and that caused by the vertical inertia forces assumed acting upward.

To determine the inertia forces and moment arms, the total mass and the center of the mass of each structure are first obtained using the SAP2000 computer program (Ref. 3-20). The acceleration coefficients used for each area structure are the peak in-structure floor accelerations at appropriate locations within respective area structures. The peak floor accelerations are from the results of the SSI analysis discussed in Section 3.2.3.1.8.

3.2.3.2.9 Analysis Procedures for Damping

The ISF Facility structures include seismic load-resisting systems of reinforced concrete, welded steel, and bolted steel. The dominant structures for the Transfer Area and the Storage Area are constructed of bolted steel and reinforced concrete, which would allow the use of a damping value equal to 7 percent of critical damping. The cask receipt crane is supported by a welded moment-resisting frame; the rest of the building is bolted steel construction. A damping value of 4 percent of critical damping is conservatively used for the design of the Cask Receipt Area.

3.2.3.2.10 Seismic Analysis of Overhead Cranes

Specific seismic design features for each ITS overhead crane are discussed in Chapter 4.

3.2.3.2.11 Seismic Analysis of Specific Safety Features

SSCs including associated features classified ITS are identified in Table 3.4-1. These features, including vertical seismic restraints for various trolleys and lateral supports for canisters and tube assemblies, are integral with the structures or major equipment. The seismic analysis for structures and major equipment described in Section 3.2.3.2.1 provides seismic responses at various locations for use in the design of these associated features. Those portions of NITS SSCs whose failure could reduce the function of an ITS feature to an unacceptable safety level are designed and constructed to prevent the design earthquake from causing such a failure.

3.2.4 Snow and Ice Loadings

The input ground snow load is based on *Ground and Roof Snow Loads for Idaho,* and on a 50-year mean recurrence interval (Ref. 3-25). The roof snow load is calculated in accordance with ASCE 7.

Ground snow load = 35 psf
Minimum roof snow load = 30 psf

3.2.5 Combined Load Criteria

Definitions of design loads and load combinations for the ISF Facility reinforced concrete and steel structures ITS are in accordance with Table 3-1 of NUREG 1536 (Ref. 3-26). These loads and load combinations are also applicable to structures NITS that could potentially compromise the integrity of ITS structures. The load combinations are provided for selected normal, off-normal, and accident conditions. Specific design loads and load combinations applicable to structures and spent fuel handling equipment are presented in Section 4.7, *Spent Fuel Handling Operating Systems*.

3.2.5.1 Design Loads

3.2.5.1.1 Dead Loads (D)

Design dead load on all facility structures includes vertical self weight of the structure and the weight of permanently attached equipment and utilities such as HVAC ducting, process and non-process piping, electrical conduits, etc.

3.2.5.1.2 Live Loads (L)

Live loads include transition loads and weights of non-permanent equipment, piping, ducting, and building occupants. Live loads may include weight and operational loads associated with handling equipment, and normal and off-normal equipment impact loads.

3.2.5.1.3 Soil Pressure (H)

Soil pressure loads include loads caused by lateral soil pressure including lateral pressure from groundwater, soil weight, and soil pressure caused by adjacent structures. Because little of the ISF Facility structures ITS are below grade, soil pressure loads are considered negligible for the analysis of ITS structures.

3.2.5.1.4 Soil Reaction Loads (G)

Soil reaction includes loads to be used only in load combinations for footing and foundation sections for which the required strength is limited by the soil reactions. The soil reaction loads are limited by the vertical maximum soil or pile bearing capacity, and the lateral passive pressure limit that would exist in normal, off-normal, or accident conditions corresponding to the load combination considered. Soil reaction loads are not explicitly used as a load case for the ISF project. Soil loads are considered in design of foundations.

3.2.5.1.5 Wind Loads (W)

Wind loads are produced by normal and off-normal maximum winds. Pressure resulting from the wind, considering wind velocity, structure configuration, height above ground, location, gusting, and importance factor is calculated using the methodologies of ASCE 7 and described in Section 3.2.1, *Tornado and Wind Loadings*.

3.2.5.1.6 Temperature Loads (T)

Thermal loads include loads associated with normal condition temperatures, temperature distributions, thermal gradients within the structure, and effects of expansion and contraction of structural elements.

Reference Temperature

The reference temperature is the temperature at which the concrete is considered to be "stress free" from thermal effects. The reference temperature is assumed to be 60°F because normal construction practices result in a temperature near this value when placing concrete for large structures. The air temperature during construction may vary during the year; however, the requirements for hot and cold weather concrete placement, together with the heat developed by the hydrating concrete, will effectively keep the temperature near this value.

Normal Site Ambient Maximum and Minimum Temperatures

Minimum normal site temperature = -26°F
Maximum normal site temperature = 98°F

Normal Indoor Temperatures

The normal indoor temperatures for the FPA and the Storage Area charge face are based on protecting equipment and providing a minimal level of comfort for operating personnel. Temperatures used for the analysis of the Storage Area are as follows:

Fuel Packaging Area	Summer temperature = 90°F Winter temperature = 50°F
Storage Area vault	Summer temperature = 109°F Winter temperature = -19°F
Storage Area above charge face	Summer temperature = 100°F Winter temperature = 40°F

3.2.5.1.7 Earthquake Loads (E)

Earthquake loads are those attributable to the direct and secondary effects of the design earthquake. Section 3.2.3, *Seismic Design*, provides bases for developing earthquake loads in the form of acceleration response spectra or time-histories at the various locations of interest for the design of structures and equipment.

3.2.5.1.8 Flood Loads (F)

Flood loads are those due to direct and secondary effects of the off-normal or design basis flood, including flooding due to severe and extreme natural phenomena, dam failure, fire suppression, and other accidents. The design basis flood loads are the hydrostatic pressures and buoyancy forces associated with the PMF water level at elevation 4920.71 feet above msl (NAVD 88) as described in Section 3.2.2, *Water Level (Flood) Design*.

3.2.5.1.9 Tornado Loads (W_t)

Tornado loads include wind pressures, pressure drop, and wind generated missiles produced by the design basis tornado are described in Section 3.2.1, *Tornado and Wind Loadings*.

3.2.5.1.10 Off-Normal and Accident Thermal Loads (T_a)

Off-normal thermal loads are those produced directly by or as a result of off-normal or design-basis accidents, fires, or natural phenomena. Although off-normal and design basis accident thermal loads are treated the same in the load combinations, there is a distinction between off-normal and design basis accident temperature limits for concrete.

Off-Normal Site Ambient Maximum and Minimum Temperatures

- minimum off-normal site temperature = -40°F
- maximum off-normal site temperature = 101°F

Off-Normal Temperatures for Transfer Area

Two off-normal events are considered for thermal stress analysis. The first case used for design is based on normal outside ambient temperatures and inside temperatures after the loss of the HVAC system. For the winter case, lights and equipment are assumed to stay on, but in the summer case, lights and equipment are assumed to be turned off.

Case 1

Outside temperatures

- minimum temperature (winter) = -26°F
- maximum temperature (summer) = 98°F

Inside temperatures (after loss of HVAC system) used for the analysis are as follows:

Location	Winter Temp. Lights and Equipment On (°F)	Summer Temp. Lights and Equipment Off (°F)
Transfer Tunnel	46	94
Operating Gallery	-4	116
Fuel Packaging and FHM Maintenance Area	48	93

Case 2

The second off-normal event used for design is based on off-normal outside ambient temperatures coupled with normal operating inside temperatures.

Outside Temperatures

- minimum temperature (winter) = -40°F
- maximum temperature (summer) = 101°F

Inside temperatures:

Location	Minimum Temp. Winter (°F)	Maximum Temp. Summer (°F)
Transfer Tunnel	50	90
Operating Gallery	70	80
Fuel Packaging and FHM Maintenance Area	50	90

Off-Normal Temperatures for Storage Area

Off-normal events in the Storage Area include:

- Plugging of the storage vault vents. For off-normal conditions, the vents are assumed to have 25-percent blockage of the air inlet and outlet ducts. For accident conditions, the vents are assumed to have 50-percent blockage of the air inlet and outlet ducts.
- Shutdown of HVAC system.
- Off-normal and accident outside ambient temperatures.

Two off-normal cases are considered for thermal stress analysis. The first case is based on normal outside ambient temperatures with loss of the HVAC system above the charge face and inside the Transfer Tunnel. For the winter case, lights and equipment are assumed to stay on, but in the summer case, lights and equipment are assumed to be turned off.

Case 1

Outside temperatures:

- minimum temperature (winter) = -26°F
- maximum temperature (summer) = 98°F

Inside temperatures:

Location	Winter Temp. Lights and Equipment On (°F)	Summer Temp. Lights and Equipment Off (°F)
Above Charge Face	-1	128
Below Charge Face	-12	120
Inside Vault (average of outside temp and charge face temp)	-19	109

Case 2

The second off-normal event used for design is based on off-normal outside ambient temperatures coupled with normal operating inside temperatures. The below charge face winter temperature was conservatively taken equal to the outside temperature.

Outside Temperature:

- Minimum Temperature (Winter) = -40°F
- Maximum Temperature (Summer) = 101°F

Inside Temperatures:

Location	Minimum Temp. Winter (°F)	Maximum Temp. Summer (°F)
Above Charge Face	40	100
Below Charge Face	-40 (outside temp)	120
Inside Vault (average of outside temp and charge face temp)	-40	111

3.2.5.1.11 Accident Loads (A)

Accident loads are those due to direct and secondary effects of an off-normal or design basis accident, as could result from an explosion, crash, drop, impact, collapse, gross negligence, or other human-caused occurrences.

3.2.5.2 Load Combinations

The following load combination have been used in the design and analysis of the ISF Facility structures, and are consistent with NUREG-1567 (Ref. 3-27), Section 4.5.3.2, and NUREG-1536, Table 3-1 (Ref. 3-26). Load combinations from industry codes and standards (e. g., CMAA-70, ASME Boiler and Pressure Vessel Code) used to analyze specific systems and components within these structures are provided in Chapter 4.

3.2.5.2.1 Reinforced-Concrete Structures

Normal conditions	$U_c > 1.4D+1.7L$ $U_c > 1.4D+1.7(L+H)$
Off-normal conditions	$U_c > 1.05\ D + 1.275\ (L + H + T)$ $U_c > 1.05\ D + 1.275\ (L + H + T + W)$
Accident conditions	$U_c > D + L + H + T +(\ E \text{ or } F)$ $U_c > D + L + H + T + A$ $U_c > D + L + H + T_a$ $U_c > D + L + H + T + W_t$ U_c represents reinforced-concrete available strength

3.2.5.2.2 Reinforced-Concrete Footing/Foundations

Normal conditions	$U_f > D + (L + G)$ $U_f > D + (L + H+ G)$
Off-normal conditions	$U_f > D + (L + H + T + G)$ $U_f > D + (L + H + T + W + G)$
Accident conditions	$U_f > D + L + H + T + E + G$ $U_f > D + L + H + T + A + G$ $U_f > D + L + H + T_a + G$ $U_f > D + L + H + T + W_t + G$ $U_f > D + L + H + T + F + G$ U_f represents strength of foundation sections

3.2.5.2.3 Steel Structures Allowable Stress Design

Normal conditions	(S and S_v) > D + L (S and S_v) > D + L + H
Off-normal conditions	1.3 (S and S_v) > D + L + H + W 1.5 S > D + L + H + T + W 1.4 Sv > D + L + H + T + W
Accident conditions	1.6 S > D + L + H + T + (E or W_t or F) 1.4 S_v > D + L + H + T + (E or W_t or F) 1.7 S > D + L + H + T + A 1.4 S_v > D + L + H + T + A 1.7 S > D + L + H + T_a 1.4 S_v > D + L + H + T_a S represents steel Allowable Stress Design (ASD) strength S_v represents steel ASD shear strength

3.2.5.2.4 Overturning and Sliding

Normal conditions and Off-normal conditions	O/S >1.5 (D + H)
Accident conditions	O/S > 1.1 (D +H + E) O/S > 1.1 (D + H + W_t) O/S represents overturning/sliding resistance

3.3 SAFETY PROTECTION SYSTEM

3.3.1 General

The ISF Facility is designed for safe and secure dry transfer and packaging, long-term confinement, and dry storage of the SNF as described in Section 3.1, *Purposes of Installation*.

The key elements of the ISF Facility and its operation that require special design considerations include:

- Designs of 3 cranes, 2 transfer trolleys, and over 24 special lifting devices are required to perform various handling and transfer operations. To minimize the potential for handling accidents, these cranes and transfer trolleys are designed as single-failure-proof cranes based on guidance in NUREG-0554, *Single-failure-proof Cranes at Nuclear Plants* (Ref. 3-28). With the exception of certain lifting devices within the fuel packaging area, the designs of the lifting devices satisfy the criteria of ANSI N14.6, *American National Standard for Radioactive Materials -Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More* (Ref. 3-29).
- Multiple designs of the ISF canisters, baskets, and other internal components are required to accommodate the various types and configurations of the SNF. This is a significant aspect because there are three entirely different types of fuels, each requiring its own basket configurations.
- Within the FPA, the layout and design of remote equipment that can unpack, handle, and package the types and configurations of fuels are required. This is a significant aspect because the operation requires the remote handling of fuel in a dry transfer system with the visual observation provided by means of shield windows or closed-circuit television cameras. The fuel is moved from existing DOE packages into ISF baskets within the FPA.
- The dry storage portion of the system requires the design of the carbon steel storage tube and concrete storage vault to serve as the passive cooling system for decay heat removal. This is a significant aspect because of the use of a concrete storage vault rather than individual concrete storage casks or modular horizontal storage units on an open concrete pad.
- A constant consideration in the design and operations process was to minimize personnel radiation exposure during the various transfer, packaging, and ISF canister closure operations. This is a significant aspect because the operation involves the handling and transferring of fuel in various dry transfer movements and work areas.

3.3.2 Protection by Multiple Confinement Barriers and Systems

3.3.2.1 Confinement Barriers and Systems

The radioactive materials that the ISF Facility confines are described in Section 3.1.1. In contrast to typical commercial reactor fuels, the effects of temperature and operating conditions on the long-term behavior of the fuel cladding are not well documented for the particular fuel types stored at the ISF Facility. Furthermore, the DOE has identified some fuels to be stored that are known to be damaged (e.g., Peach Bottom 1 fuel with attached removal tools). Therefore, FWENC has chosen not to rely on the fuel cladding as a confinement barrier in the design of the ISF Facility. Instead, all fuels will be placed in sealed canisters, consistent with the fuel canning requirements in 10 CFR 72.122(h)(1) and Interim Staff

Guidance 1, *Damaged Fuel* (Refs. 3-1 and 3-30). The multiple barriers listed in Table 3.3-1 confine these radioactive materials during storage. The following paragraphs further describe these barriers and systems as the SNF progresses from receipt at the ISF Facility until it enters dry storage.

3.3.2.1.1 Existing DOE Transfer Cask

The confinement characteristics of the DOE transfer cask are described in Appendix A, *Safety Evaluation of the DOE-Provided Transfer Cask.*

3.3.2.1.2 Fuel Packaging Area

The FPA serves as the confinement barrier and system while SNF is removed from the DOE-supplied containers until the loaded ISF basket and shield plug are placed inside the ISF canister. This confinement barrier consists of the concrete walls of the FPA and FHM maintenance area, shield windows, ports (cask port, storage canister port, waste port, and process waste port), HEPA filters (FPA supply and exhaust, FHM Maintenance Area supply), through wall penetrations associated with the concrete walls, personnel shielded access door, roof penetrations for lifting rods associated with the packaging area shield door, hoist well, and inflatable seals between the bottom of the cask port and the cask or between the bottom of the canister port and the canister trolley when these ports are open.

The various SSCs that are part of the confinement barrier and system are evaluated for the postulated internal accidents or natural phenomena associated with the ISF Facility. These evaluations confirm that the confinement barriers remain in place or that loss of these barriers results in releases that are below limits defined in 10 CFR 72. The building structural evaluations are provided in Chapter 4, *Installation Design.* The dose and accident assessments are provided in Chapter 7, *Radiation Protection,* and Chapter 8, *Accident Analysis*.

The structural design criteria associated with these SSCs are defined in Chapter 4.

The design is based on achieving a direct annual dose of 1000 mrem or less at the outside surface of the concrete walls and shield windows during normal operations and demonstrating that dose levels at the INEEL site boundary are below 10 CFR 72 limits for postulated off-normal and accident conditions (Ref. 3-1).

The ventilation design criteria (see Section 3.3.2.2) require that the airflow is such that estimated releases of airborne radionuclides within the FPA are filtered by the HEPA filters within the FPA, the intermediate HEPA filters, and the final HEPA filters.

The confinement approach utilizes the overall guidance provided in Interim Staff Guidance 5 Revision 1, *Confinement Evaluation* (Ref. 3-31).

3.3.2.1.3 Lower Subassembly of ISF Canister Containing a Loaded Basket and Shield Plug

The lower subassembly (approximately 80 percent of the total height) of the ISF canister, basket structure, and shield plug impede contamination migration while SNF is in the lower subassembly of the ISF canister before the completion of the closure weld and seal weld of the ISF canister.

The various SSCs that are part of the confinement barrier and system are evaluated for the postulated internal accidents or natural phenomena associated with the ISF Facility. These evaluations confirm that the confinement barriers remain in place or that loss of these results in releases that are below limits defined in 10 CFR 72 (Ref. 3-1). The structural evaluations are provided in Chapter 4, *Installation Design*. The dose and accident assessments are provided in Chapter 7, *Radiation Protection* and Chapter 8, *Accident Analysis*.

The structural design criteria associated with these SSCs are defined in Chapter 4.

The direct dose through the ISF canister, shield plug, Transfer Tunnel, and shielding provided during the canister closure operations is part of the overall dose for workers at the ISF Facility. For the ISF canister, worker dose may be estimated by a combination of the amount of fuel in a given ISF canister, the internal basket configuration and self-shielding within the ISF canister, the shielding provided by SSCs external to the ISF canister at the CCA, and the time required for completion of the various canister closure operations. The overall dose limit from all sources is 1000 mrem/year for workers at the ISF Facility.

The estimated release of airborne radionuclides to the Transfer Tunnel or CCA is based on the airflow through the gap between the inside wall of the ISF canister and the outside diameter of the shield plug. The airflow is a result of the natural convection of the air being heated by the decay heat of the spent fuel and the canister heater. The radionuclide compositions for the SNF are described in Section 7.2.

The ventilation design criteria (see Section 3.3.2.2) require that the airflow is such that estimated releases of airborne radionuclides within the Transfer Tunnel and CCA are filtered by intermediate HEPA filters located in these areas and the final HEPA filters.

The confinement approach utilizes the overall guidance in Interim Staff Guidance 5, Revision 1, *Confinement Evaluation* (Ref. 3-31).

3.3.2.1.4 Sealed ISF Canister

The ISF canister, Transfer Tunnel, and CHM serve as the confinement barrier and system between the time the ISF canister leaves the CCA and the time it is placed inside the storage tube. The ISF canister is vacuum dried, backfilled with helium, and helium leak tested.

The various SSCs that are part of the confinement barrier and system are evaluated for the postulated internal accidents or natural phenomena associated with the ISF Facility. These evaluations confirm that the confinement barriers remain in place or that loss of these results in releases that are below limits defined in 10 CFR 72 (Ref. 3-1). The structural evaluations are provided in Chapter 4, *Installation Design*. The dose and accident assessments are provided in Chapter 7, *Radiation Protection,* and Chapter 8, *Accident Analysis*.

The structural design criteria associated with these SSCs are defined in Chapter 4.

Worker dose is the same as that described in Section 3.3.2.1.3.

The ventilation design criteria for the Transfer Tunnel are the same as in Section 3.3.2.1.3. The Storage Area is at atmospheric pressure with an upward airflow due to the natural convection of the air in the Storage Area being heated by the decay heat of the spent fuel.

The confinement approach utilizes the overall guidance provided in Interim Staff Guidance 5, Revision 1, *Confinement Evaluation* (Ref. 3-31).

3.3.2.1.5 Storage Tube and ISF Canister

The storage tube and ISF canister serve as the confinement barrier and system during the period of dry storage. The ISF canister is the primary confinement boundary, with the storage tube providing secondary confinement during storage.

The various SSCs that are part of the confinement barrier and system are evaluated for the postulated internal accidents or natural phenomena associated with the ISF Facility. These evaluations confirm that the confinement barriers remain in place or that loss of these results in releases that are below limits defined in 10 CFR 72 (Ref. 3-1). The structural evaluations are provided in Chapter 4, *Installation Design*. The dose and accident assessments are provided in Chapter 7, *Radiation Protection,* and Chapter 8, *Accident Analysis*.

The structural design criteria associated with these SSCs are defined in Chapter 4.

The direct dose through the ISF canister, shield plug, storage tube assembly, and concrete storage vault during the dry storage time period is part of the overall dose for workers at the ISF Facility. For the ISF canister, worker dose may be estimated by a combination of the amount of fuel in a given ISF canister, the internal basket configuration and self-shielding within the ISF canister, and the shielding provided by SSCs external to the ISF canister. The overall dose limit from all sources is 1000 mrem/year for workers at ISF Facility.

The storage tube is vacuum dried, backfilled with helium, and helium leak tested. The helium-filled storage tube provides an inert environment for corrosion control.

The Storage Area is at atmospheric pressure with an upward airflow due to the natural convection of the air in the Storage Area being heated by the decay heat of the SNF.

The confinement approach utilizes the overall guidance in Interim Staff Guidance 5, Revision 1, *Confinement Evaluation*.

3.3.2.2 Ventilation and Off-Gas Systems

3.3.2.2.1 Criteria Selected for Providing Suitable Ventilation for Fuel Handling and Storage Structures

The criteria selected for providing suitable ventilation for fuel handling and storage structures are defined below.

3.3.2.2.2 Capacity Standards for Normal and Off-Normal Conditions

System capacities are designed to meet requirements for airborne contamination control, ventilation, heating, and cooling under normal and off-normal operating conditions except for the off-normal conditions involving loss of the HVAC systems.

With respect to airborne contamination control, the ISF Facility has defined airborne contamination control zones and established a HVAC design criterion that airflow must travel from the zone with the least potential for contamination to the zone with the highest potential for contamination.

The ventilation design criteria for normally occupied areas in the secondary contamination control zone (these contamination control zones are defined in the next section) requires a minimum of four (4) air changes per hour as recommended in the *ASHRAE Design Guide for Department of Energy Nuclear Facilities* (Ref. 3-32).

The heating and cooling criteria (minimum and maximum area temperatures) of the HVAC system design are described in Section 4.3.1.

3.3.2.2.3 Zone Interface Flow Velocity & Differential Pressure Standards

The ISF Facility is divided into four airborne contamination control zones with varying degrees of hazard:

- an inner (primary or zone 1) contamination control zone where radioactive materials are remotely handled and packaged
- an intermediate (secondary or zone 2) contamination control zone where some potential for radioactive release may exist
- an outer (tertiary or zone 3) contamination control zone where there is little potential for radioactive release
- a radioactively clean (ancillary or zone 4) area surrounding the tertiary zone.

The HVAC systems are designed to establish decreasing pressures between the four zones so that differential pressure creates inward airflow from a higher numbered zone to a lower numbered zone. Chapter 4 describes the features of the HVAC system in greater detail.

3.3.2.2.4 Flow Pattern

The HVAC design establishes flow patterns from the higher numbered (less contaminated) contamination control zone to the lower numbered (more contaminated) contamination control zone.

3.3.2.2.5 Control Instrumentation

Room pressures are maintained by varying the amount of supply air delivered to the room. The amount of exhaust air remains constant. The total volume of supply air is always less than the total volume of exhaust air. The supply fan is interlocked with the exhaust fan and does not run unless the exhaust fan is running.

The redundant supply fans are interlocked to prevent simultaneous operation. A similar interlock exists for the redundant exhaust fans.

The control system monitors room pressure, initiates alarms, and automatically shuts down the supply fan if a positive pressure is detected in either a primary or secondary contamination control zone.

3.3.2.2.6 Criteria for the Design of the Ventilation and Off-Gas Systems

The ventilation and off-gas systems have the following design criteria. Table 3.3-2 summarizes how these criteria are applied to the five confinement boundaries defined in Section 3.3.2.1.

3.3.2.2.7 Airflow Patterns and Velocity with Respect to Contamination Control

As noted in Section 3.3.2.2.3, the ISF Facility is classified into four airborne contamination control zones. The ventilation systems are designed to ensure that room pressures establish airflow from the areas of least expected contamination to most expected contamination. The velocity when doors, ports, or plugs are opened must be such that this airflow direction is maintained.

3.3.2.2.8 Minimum Negative Pressures at Key Points in the System to Maintain Proper Flow Control

The minimum negative pressure differentials at key interfaces between adjacent zones are:

- zone 4 to zone 3 (-) 0.05 inch w.g.
- zone 3 to zone 2 (-) 0.10 inch w.g.
- zone 2 to zone 1 (-) 0.20 inch w.g.

3.3.2.2.9 Interaction of Off-Gas Systems with Ventilation Systems

A single off-gas system is provided. The HVAC systems that may contain contamination connect to the final HEPA filters that in turn connect to the exhaust stack by ductwork. The ductwork from the final HEPA filters out through the exhaust stack is welded construction.

The exhaust stack height is determined by calculation and plume dispersion modeling to ensure that radiation levels at the site boundary do not present a risk to the health and safety of the public. The exhaust stack contains an isokinetic sampler and sample ports. The sample ports are located 90 degrees apart, at least 8 stack diameters above the inlet and at least 2 stack diameters below the outlet.

3.3.2.2.10 Minimum Filter Performance with Respect to Particulate Removal Efficiency and Maximum Pressure Drop

HEPA filters are installed within the FPA on the exhaust ducts leaving the room. These filters act as pre-filters to protect the downstream ductwork from contamination and serve as part of the confinement boundary. When a change is required, a filter is isolated by a downstream damper and changed remotely with a manipulator controlled from the operating gallery. The HEPA filters do not require aerosol testing because they are used as intermediate filters.

Additional HEPA filters installed in other areas protect supply and exhaust ductwork from contamination and to restrict backflow through the supply ducts should the downstream rooms become pressurized.

HEPA filters are installed immediately upstream of the exhaust air discharges to the exhaust stack. These filters are the final filtration point for removing radioactive particles from the exhaust air. Each final filter unit consists of one stage of pre-filters followed in series by two stages of HEPA filters. The HEPA filters, housed in metal enclosures, are Type B nuclear grade and meet the requirements of ANSI N509 and ANSI N510 (Refs. 3-33 and 3-34). Isolation dampers are installed between parallel banks of HEPA filters to facilitate filter changes. Instrumentation on the filter housing monitors temperatures, flow rates, and differential pressures (dust loading). Injection and sample ports accommodate in-place aerosol efficiency tests.

Typical design operating conditions for HEPA filters are 90°F, 90 percent relative humidity, and 1.3 inches w.g. differential pressure at 1500 cfm.

3.3.2.2.11 Minimum Performance of Other Radioactivity Removal Equipment

The ductwork does not act as removal equipment, but it is integral to the overall HVAC system function and meets the requirements discussed below.

Supply ductwork serving zones 1 and 2 is fabricated and installed in accordance with SMACNA's high-pressure duct construction standards due to the pressures involved (Ref. 3-35). All ductwork is galvanized steel with a minimum 1-inch duct liner for thermal insulation.

Exhaust ductwork serving zones 1 and 2 is fabricated and installed in accordance with ERDA 76-21 (Ref. 3-36), ASME N509, and SMACNA's high-pressure duct construction standard. Ductwork design is based on high (Class 2) contamination levels in the ductwork between the FPA and the final HEPA filters, moderate (Class 3) contamination levels in all other areas, and an operating mode in which the exhaust system is shut down in case of an accident. Ductwork from the FPA to the final HEPA filters is welded construction (Class 4) due to potential contamination. Ductwork from the final HEPA filters to the exhaust stack is welded construction due to the pressures involved.

3.3.2.2.12 Minimum Performance of Dampers and Instrumented Controls

Dampers in ductwork serving zones 3 and 4 are, as a minimum, commercial-quality (Class D) construction in accordance with ERDA 76-21. Dampers in the supply ductwork serving Zones 1 and 2 are, as a minimum, commercial-quality (Class D) construction with the exception of the isolation dampers on the intermediate HEPA filters, which are industry-quality (Class C, Group 1-A) construction. Dampers in the exhaust ductwork serving zones 1 and 2 are industrial-quality (Class C) construction with the exception of the isolation dampers for the FPA HEPA filters, which are ASME N509 (Class A, Group 1) construction.

Tornado dampers installed at ductwork penetrations into the FPA automatically close in the event of a tornado. These dampers are designed to prevent the release of contamination due to pressure differentials.

Radiation monitoring devices on the exhaust stack and the recirculating heating and cooling units initiate alarms locally and in the operations monitoring area if airborne radiation exceeds allowable levels.

A direct digital control (DDC) system controls and monitors HVAC systems throughout the facility. The DDC system permits centralized programming, monitoring, alarm annunciation, and trending of the HVAC processes. It also transmits data to other systems such as the fire detection, radiation monitoring, and site security systems.

The HVAC system employs electric controls and actuators for all control functions. Analog and digital field devices gather data for system control, status, monitoring, and alarm. Input data include temperatures, pressures, flow rates, damper and valve positions, and equipment status. The DDC system control algorithms manipulate this data and send digital output signals to electric damper and valve actuators, variable frequency drives, silicon controlled rectifiers, and similar output devices for corrective action. The HVAC system uses no pneumatic control devices.

3.3.3 Protection by Equipment and Instrumentation Selection

3.3.3.1 Equipment

Key equipment specifically selected to provide protection to the SNF is summarized in Table 3.3-3. Key subsystems or components for key equipment are provided along with the key design criteria. Additional design criteria and further discussions of subsystems and components are provided in Chapters 4, 5, and 8.

3.3.3.2 Instrumentation

The instrumentation and controls for significant SSCs are described in Section 5.4. In accordance with 10 CFR 72.122, the controls philosophy for ITS designated equipment prohibits any single failure to either cause a loss of safety function or to impair the mitigation of a failure event (Ref. 3-1). All control systems with single-failure-proof requirements are implemented using redundant controls that prohibit a single failure from affecting the ability of the system to perform its safety function. Typically redundancy will be accomplished through the use of two control channels, which are electrically independent and physically separated to the extent necessary for each channel to remain uninfluenced by equipment failure, short circuit, overload, or fire on the opposing channel.

Instrumentation requirements to support the key equipment listed in Table 3.3-3 are provided in Table 3.3-4.

3.3.4 Nuclear Criticality Safety

10 CFR 72.124 requires that spent nuclear fuel storage facilities be designed for criticality safety, incorporate appropriate methods of criticality control, and include criticality monitoring systems where spent nuclear fuel is handled or stored. For typical commercial fuels, these requirements are to be met by:

- Ensuring that at least two unlikely, independent and concurrent or sequential changes must occur in the conditions essential to nuclear criticality safety before a nuclear criticality accident is possible;
- Including margins of safety for nuclear criticality parameters that are commensurate with the uncertainties in the data and methods of analysis;

- Basing designs on the use of favorable geometry, permanently fixed neutron absorbing materials, or both; and
- Including criticality monitoring and alarm systems in areas where spent nuclear fuel is handled and/or stored.

Commercial fuels typically consist of low enrichment (2.5% to 8%) ^{235}U in a UO_2 matrix. Large numbers of small UO_2 pellets are loaded into long narrow zirconium alloy tubes, which form the fuel cladding. Each tube, or rod, is seal welded and placed into an array along with 100 or more similar rods.

The fuels to be stored at the ISF Facility differ from commercial fuels in several ways that could potentially impact criticality safety.

- **TRIGA Fuel.** TRIGA fuel elements consist of a UZrH slug, containing 8 to 9 weight percent uranium enriched to 20% ^{235}U. This slug is placed between two solid graphite reflectors and loaded into a stainless steel or aluminum outer shell that forms the fuel element cladding. The higher enrichment, UZrH fuel composition and relatively small size (approximately 30 inch total length) make the TRIGA elements more reactive than typical commercial fuels.
- **Peach Bottom Fuel.** Peach Bottom fuel elements consist of small microspheres of uranium carbide enriched to over 93% ^{235}U, embedded into solid annulus-shaped graphite compacts. These annular compacts are loaded onto a central graphite spine that runs the length of the fueled region of the element. An upper and lower graphite reflector is placed above and below the fueled region. A pyrolytic carbon sleeve holds the element together and acts as the outer cladding. Although the Peach Bottom fuel contains a higher enrichment than typical commercial fuels, the wide dispersion of the fissile material within the element and its carbon composition make it less reactive than typical commercial fuel. The key concern with the Peach Bottom fuel is the relatively low initial strength and possible embrittlement of the graphite sleeve as compared to typical metallic fuel claddings; therefore, unfavorable geometries could potentially be created by structural failure of the fuel element.
- **Shippingport Reflector Modules.** Shippingport Fuel Reflector Modules are similar in design to commercial fuel assemblies, with the key difference that the assemblies contain ThO_2 pellets instead of UO_2 pellets. As there is no initial fissile material loading, and very little in-breeding of ^{233}U during reactor operations, the Shippingport Reflector assemblies do not pose criticality concerns.

The ISF Facility has used standard criticality control methods in the design basis for the facility, incorporating additional analyses and evaluations as appropriate to deal with the unique nature of the fuels to be handled and stored. In particular, the ISF Facility design:

- Ensures that at least two unlikely, independent and concurrent or sequential changes must occur in the conditions essential to nuclear criticality safety before a nuclear criticality accident is possible. Criticality evaluations specifically considered fuel handling events particular to the unique fuel types to be stored to ensure that the double-contingency criteria would be achieved. These included analyzing criticality scenarios involving structural failure of the Peach Bottom elements.

- Includes margins of safety for nuclear criticality parameters that are commensurate with the uncertainties in the data and methods of analysis. Calculations have been performed using an industry-standard computer code (MCNP4B), benchmarked to fuels that are similar to the those to be handled at the ISF facility. The results of the calculations incorporate appropriate margins for uncertainty and bias in the calculations based on these benchmarks. Burnup of these fuels was not credited in the calculations for maintaining criticality safety.
- Ensures favorable geometry to prevent criticality. The design of fuel handling and storage areas incorporates engineered features to ensure that favorable geometries are maintained during handling and storage conditions. Permanently fixed neutron absorbing materials present in the storage containers to meet repository requirements are not credited in the ISF Facility criticality safety calculations.
- Includes appropriate criticality monitoring and alarm systems.

Criticality safety analyses that consider the above features required by 10 CFR 72.124 have demonstrated that there are adequate safety margins for handling and storage operations involving the specific fuel types present at the ISF Facility.

3.3.4.1 Control Methods for Prevention of Criticality

The control methods for prevention of criticality are based on either limitation of the amount of fissile material or engineered features. Criticality safety of the system does not rely on the use of burnup credit. Criticality safety of the system does not rely on the use of burnable or fixed neutron absorbing materials (poisons).

Five design criteria are applied to the SNF from arrival at the ISF Facility to storage in the concrete vault. Table 3.3-5 summarizes where each design criteria is considered. Chapter 4 provides the detailed discussion of the design as well as the criticality considerations.

3.3.4.2 Error Contingency Criteria

The multiplication factor (k_{eff}), including all biases and 2σ uncertainty does not exceed 0.95 at a 97.5 percent confidence level under all credible normal, off-normal, and accident conditions.

3.3.4.3 Verification Analyses

The criteria used for establishing the verification of models or programs used in the criticality analyses are provided below.

3.3.4.3.1 Verification Analyses Associated with the Existing DOE Transfer Cask(s)

Criticality safety features of the DOE transfer cask are described in Appendix A, *Safety Evaluation of the DOE-Provided Transfer Cask.*

Verification of the criticality analysis for the DOE Transfer Cask is addressed in Appendix A.

3.3.4.3.2 Verification and Validation of Computing Techniques

The verification of the mathematical models embedded in the computer code was acceptably tested to ensure that the design analysis application is acceptable. Validation is intended to demonstrate that software has been properly coded, installed on a computer, and performs the intended functions for a given set of input. Validation of the reliability of the computer programs used for performing safety calculations is assured by comparing the calculation results for identical cases between computers and periodically for identical cases on the same computer. All computers used in performing criticality safety calculations have installed on them the same version of the MCNP4 Monte Carlo code (Ref. 3-37) and the ENDF/B library (Ref. 3-38), and have been shown to provide the same results.

The objective of the validation activity is to determine the difference between the experiment k_{eff} (usually k_{eff} =1.0000) and the k_{eff} calculated for the experiment, and using this to determine the lower confidence band on the data. This is then used to set the maximum safe calculated k_{eff} for a safety analysis.

The computational method combining the MCNP4B code using the ENDF/B-VI cross section library has been validated for calculations for several different fissile materials. These materials include plutonium experiments with ^{240}Pu no greater than 8 weight percent, fully enriched uranium experiments with ^{235}U about 93 weight percent in uranium, and ^{233}U experiments. Additional highly enriched uranium (HEU) experiments, intermediate enriched uranium, and ^{233}U experiments have been added to the original HEU database to represent the ISF fuel in determination of the bias of the computational method and the subcritical limit. The subcritical limit is based on the validation results of the code and cross sections used on the computers performing criticality safety calculations. Since the spent fuels committed to the ISF program are differently configured than the earlier experiments, the additional evaluated experiments were added to the experiment data set to show that the safety limit is not compromised by including experiments appropriate to the ISF fuel with the original data set.

Code validation is required to meet several national standard and quality assurance requirements. National Standard ANS 8.1 requires that calculation methods used for criticality safety analysis be validated and that any bias must be determined by correlating the calculations to experimentally determined results (Ref. 3-39). Several sources exist for determining safe limits for handling fissile material outside of reactors, but these provide limits only for simple systems and are normally limited to single bounding conditions. Such limits are often too restrictive to be practical or economical. In order to provide less restricting limits, many fissile material operations can be shown to be safe with higher limits than found in these standard references by using two or more bounding conditions. It is not normally possible to determine such safe limits to an operation without using a flexible, validated computational method that is capable of performing calculations involving complex geometry and compositions.

Experiments used in this validation study are taken from experiment evaluations or input databases developed by the International Criticality Safety Benchmark Evaluation Program (ICSBEP) (Ref. 3-40). Using this data source has several advantages. Because the evaluations are peer reviewed, both within the authoring organization and by an independent technical reviewer, workup of basic data is not required and the chances of error are minimized. Using the input database also minimizes the chances of errors in input for a specific computer code. Selected experiments have been obtained from reviews of the available evaluations. In the original ISF project validation, a total of 128 HEU experiments with ^{235}U weight percents in uranium of 89 or greater were taken as input listings from either the input database, or (because input listings for all cases were not available in the database) from input listings in individual evaluations. Although the earlier evaluations contained listings of all cases developed in the evaluations, later evaluations contain only examples. If any cases were not found in either source, no attempt was made to develop the input for those cases because a sufficient number of cases was obtained from those available. All input listings were reviewed to ensure that they accurately reflected the reported data and were modified when necessary. The calculations have all been standardized at a total of 800,000 neutron histories calculated for each of the cases that have been identified.

The experiments included fissionable material compositions ranging from hydrogen-to-fissile-atom ratio (H/Fissile) equal to 0 (metal) to H/Fissile equal to 2800 (very dilute solutions). Experiments with close reflectors of thick water, thick concrete including partial reflectors, and thin stainless steel were included. Shapes included spheres, cylinders, and slabs, and two-dimensional arrays of cylindrical tanks and three-dimensional arrays of cylinders as part of the data set. Some evaluated experiments that had interfaces of strong neutron absorbing material were excluded because it was considered that these experiments might incorrectly bias results intended to be applied to systems without neutron absorbers.

The final result of the criticality benchmark calculations is that the k_{eff} of no operation was calculated to be greater than 0.95 including the difference between 1.0000 and the lower confidence band. For MCNP4B (Ref. 3-37) using the ENDF/B-VI cross-section library (Ref. 3-38) this would be

$$(k_{calc} + 2\sigma_{calc}) + \Delta k_{val} \leq 0.95$$

where k_{calc} is the calculated k_{eff} for the system being analyzed and σ_{calc} is its associated uncertainty, and Δk_{val} is the margin from 1.0000 required by the validation, or 1.0000 minus the k_{eff} value of the lower confidence band. From the original validation results, Δk_{val} is 1 minus 0.983, or 0.017, for uranium calculations. Entering this value in the above equation and adjusting the relationship, the determination of the safe calculated k_{eff} for a safety analysis (including contingencies) is that:

$$\text{for HEU: } k_{calc} + 2\sigma_{calc} \leq 0.933$$

The k_{eff} calculated using the MCNP code in the new group of HEU evaluations shows that the calculated values are within the spread of calculated k_{eff} in the original validation.

3.3.5 Radiological Protection

ISF Facility design, administrative control, and personnel training provide the necessary radiological protection to maintain public and occupational doses As Low As Reasonably Achievable (ALARA) during transfer and storage of SNF and associated high level radioactive material.

Design personnel use ALARA checklists to ensure the implementation of ALARA philosophy in the ISF Facility design. The checklists serve as tools in aiding design personnel to consider features that may be included to reduce worker exposure and enhance the overall safety of the ISF Facility.

Chapter 7 provides further details on design and procedural considerations for radiation protection for public and occupational doses resulting from the ISF Facility operations.

3.3.5.1 Access Control

The peripheral fence enclosing the ISF Facility defines the boundary of a restricted area that limits access for the purpose of protecting individuals against risks of exposure to radiation and radioactive materials. The restricted/exclusion area boundary is shown in Figure 4.1-1.

Access to the restricted area is granted only to authorized persons. The ISF Facility Physical Protection Plan describes the methods and devices used to control access to the restricted area, including detection, assessment, and response to unauthorized access.

From the boundary of the restricted area, a controlled area extends to the limits of the INEEL site. The controlled area boundary coincides with the INEEL site boundary and is consistent with the controlled area boundary established by the DOE for the nearby TMI-2 ISFSI (Ref. 3-14). FWENC exercises control over this area via agreements with the DOE.

Table 3.3-6 summarizes the criteria for radiological protection design applicable for the restricted and the controlled areas.

3.3.5.2 Shielding

Maintaining radiation doses ALARA is an ISF Facility design constraint. The design accommodates ALARA considerations through the use of concrete and steel structures. Where these structures are not sufficient to provide protection, the design provides for additional measures such as dedicated shielding or remote operation.

An estimate of collective doses (in person-rem) per year in each area and for major operations is provided in Chapter 7.

3.3.5.3 Radiological Alarm Systems

Radiological monitoring and contamination control at the ISF Facility ensure that radiation exposure and release limits prescribed by 10 CFR 20 are not exceeded (Ref. 3-41). Monitoring employs, as appropriate, fixed area radiation monitoring (ARM) instrumentation and continuous airborne monitoring (CAM) instrumentation.

Fixed ARM instrumentation is located in key areas of the facility. ARMs are generally in frequently occupied areas with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates before personnel enter the area. Alarm setpoints are established by evaluating the nominal area dose rate. A typical setpoint could be twice the nominal background dose rate or it may be a fixed area dose rate that triggers an alarm to notify personnel if exceeded. The alarm is visual and audible locally with a corresponding signal to the IDCS. ARMs may also trigger local and facility interlock alarms.

Dedicated criticality monitoring is provided in the Fuel Packaging Area. The criticality alarm trip point is high enough to minimize alarms from sources other than criticality and low enough to detect the minimum accident of concern. The setpoints for criticality monitors are based on critical exposure levels, monitor position, and the distance between monitors and potential sources.

Air sampling and monitoring is required by 10 CFR 20.1703(a)(3)(i) to evaluate airborne hazards whenever respiratory protective equipment is used to limit intakes in accordance with 10 CFR 20.1702 (Ref. 3-41). Air sampling and monitoring is also performed in situations where respiratory protection is not required but the airborne radioactivity level can fluctuate and early detection of airborne radioactivity could prevent or minimize intakes. A CAM is installed in occupied areas where facility personnel without respiratory protection are likely to be exposed to a concentration of radioactivity in air exceeding 40 derived air concentration (DAC) hours in a day or where there is a need to alert potentially exposed workers to unexpected increases in the airborne radioactivity levels. CAMs are used to detect breakthrough of the HEPA filters downstream of the FPA.

Each CAM is configured with a setpoint appropriate to its primary function. For CAMs that monitor occupied work areas, the setpoint is some level of activity above the established background. Typical alert and alarm setpoints are 10 and 33 percent of DAC, respectively. A CAM alarm in a work area prompts an evacuation of the immediate area per administrative procedures. Response to an alarm is determined by administrative procedures. For CAMs that monitor the discharge air downstream of the HEPA filters from the FPA, a setpoint is assigned that indicates breakthrough of the filters and prompts maintenance activity.

Record sampling and continuous air monitoring is performed at the exhaust stack. Collection and analysis of the filters is a manual procedure and there are no interlocks or alarms associated with the record sampler. In the event that laboratory results indicate above-normal activity, administrative procedures determine the appropriate response actions. The CAMs that monitor stack releases have alarm setpoints that will indicate potential radiation releases. Typical alert and alarm setpoints are 50 and 100 percent of the 10 CFR 20 Appendix B, Table 2 effluent concentrations daily limit above background, respectively.

3.3.5.4 Proximity to Other Nuclear Facilities

The ISF Facility is adjacent to INTEC which contains several individual nuclear facilities. These facilities, along with others located several miles away, are described in Chapter 2. A design criterion of the ISF Facility requires that the cumulative annual whole body dose equivalent to any individual located at the controlled area boundary not exceed 25 mrem. This criterion complies with the requirements of 10 CFR 72.104.

3.3.6 Fire and Explosion Protection

Explosions internal and external to the ISF Facility are not considered credible, as described in Chapter 8. Fire protection design features of the facility comply with 10 CFR 72.122 as described below (Ref. 3-1).

ITS SSCs are typically robust devices that are largely impervious to the types of fires considered credible for the ISF Facility. Where the performance of a safety function depends upon control instrumentation, e.g., a limit switch, the design employs redundant circuits that are independent and physically separated.

Where practical, equipment within the facility is constructed of noncombustible and heat-resistant materials. Fire barriers contain a fire at its point of origin and prevent its spread to adjacent areas. Operating procedures minimize the amount of combustible material within the facility by establishing housekeeping standards and restricting the use of flammable consumables. For example, the amount of fuel carried by the DOE Transfer Cask transporter is limited to a small amount to limit the magnitude of a potential fire.

The ISF Facility employs a fire suppression system with a site-wide water header supplying hydrants, automatic sprinklers in selected locations, and several standpipes with hose connections. To avoid the possibility of inadvertent criticality, automatic suppression devices are not installed in areas such as the FPA where water might contact or surround SNF. INTEC is the source of fire-fighting water to the ISF site through two independent water mains. A fire detection system provides prompt indication of a fire and generates local and remote alarms to summon a response from the INEEL fire department.

The fire suppression system has redundant pumps and supply piping to lessen the likelihood of system failure. Within the ISF site, valves at various points in the ring header can isolate damaged sections. In the unlikely event of a total system failure, the facility is equipped with portable fire extinguishers at various locations.

An inadvertent actuation of the suppression system could cause failure of electrical equipment through water impingement or immersion. The facility's design accommodates this possibility by configuring facility equipment to fail into a safe condition or loss of electrical power.

In accordance with NUREG 0800 and NFPA 801 (Refs. 3-12 and 3-42), a Fire Hazards Analysis (FHA) was prepared. The FHA forms the basis for the overall fire protection design, including building occupancies, building construction, primary and secondary means of suppression, and combustible loading. Detailed design features and requirements of each element of the Fire Protection System are discussed in Chapter 4. The off-normal and accident conditions involving fire are discussed in Chapter 8.

3.3.7 Materials Handling and Storage

3.3.7.1 Spent Fuel or High-Level Radioactive Waste Handling and Storage

This section provides descriptions and design criteria for the key systems used in the handling and storage of SNF.

Table 3.3-7 summarizes the SNF handling and storage system design criteria with respect to: 1) cooling requirements for the SNF, 2) onsite movement criticality control, 3) contamination control, and 4) ability to handle damaged fuel or waste containers for the key equipment. Key equipment is identified in Section 3.3.3.1.

In addition to the criteria discussed above, SSCs that contain or handle SNF have passive heat removal capability that is inherently reliable and able to be tested.

With respect to SNF retrievability, design criteria differentiate between two situations. During handling and packaging operations, an individual fuel element (for intact fuel) or an individual fuel fragment (for non-intact fuel) can be retrieved and placed in a basket. Once SNF is sealed within an ISF Canister, the lowest level of retrievability is the canister.

3.3.7.2 Radioactive Waste Treatment

The radioactive waste treatment criteria as defined in NRC Regulatory Guide 3.48 are listed in Table 3.3-8 together with a description of their implementation at the ISF Facility (Ref. 3-43). Chapter 6 discusses the specific facility design.

3.3.7.3 Waste Storage Facilities

No long-term waste storage occurs at the ISF Facility. The facility's waste processing capabilities are detailed in Chapter 6.

3.3.8 Industrial and Chemical Safety

Industrial and chemical safety standards for the ISF project are governed by Occupational Safety and Health Administration Standards 29 CFR 1910 (Ref. 3-44), and 29 CFR 1926 (Ref. 3-45), and managed under FWENC's Health and Safety Program. Subpart H, Hazardous Materials and Subpart–Z, Toxic and Hazardous Substances, specifically address chemical safety.

An Integrated Safety Management System (ISMS) conforming to 48 CFR 970.5204-2, *Integration of Environment, Safety, and Health into Work Planning and Execution*, provides an overall graded approach to environmental safety and worker health and safety (Ref. 3-46).

During operation of the ISF, hazardous chemical substances will not be introduced into the facility without review, approval, and appropriate control measures. Decontamination operations are conducted with materials that will not create Resource Conservation and Recovery Act (RCRA) wastes.

Appropriate sections of 10 CFR 40 regarding protection of the environment are applicable to the ISF Facility and are implemented through compliance with the following Federal Acquisition Regulations (Refs. 3-47 and 3-46):

52.223-2	Clean Air And Water	Apr 1984
52.223-3	Hazardous Material Identification And Material Safety Data	Jan 1997
52.223-5	Pollution Prevention And Right-To-Know Information	Apr 1998
52.223-13	Certification Of Toxic Chemical Release Reporting	Oct 1996
52.223-14	Toxic Chemical Release Reporting	Oct 1996
52.236-13	Accident Prevention	Nov 1991
952.223-71	Integration Of Environmental, Safety And Health Into Work Planning And Execution	Apr 1984

In addition to the industrial safety provisions described above, administrative controls and design features also provide for access to the facility by offsite emergency services such as ambulance service, fire departments, and law enforcement agencies.

3.4 CLASSIFICATION OF STRUCTURES, SYSTEMS, AND COMPONENTS

ISF Facility SSCs are classified either ITS or NITS. In accordance with 10 CFR 72.3, SSCs are classified ITS if they have a feature that functions to:

- maintain the conditions required to store SNF or high-level radioactive waste safely
- prevent damage to the SNF or the high-level radioactive waste container during handling and storage
- provide reasonable assurance that SNF or high-level radioactive waste can be received, handled, packaged, stored, and retrieved without undue risk to public health and safety

In addition, SSCs are classified ITS if their failure could:

- directly result in the loss of a function necessary to store SNF safely
- directly result in the loss of a function necessary to prevent damage to the SNF container
- result in a condition adversely affecting public health and safety

SSCs classified NITS do not meet an ITS criterion. Table 3.4-1 identifies and justifies SSCs classified ITS. For clarity, the SSCs are grouped by their location within the facility. The design considerations of SSCs considered ITS are discussed in Chapter 4.

Requirements for the design, fabrication, erection, maintenance, and testing of ITS SSCs are described in the *Quality Program Plan* (Ref. 3-48).

With the exception of the ISF Baskets, all ITS fuel storage components are designed and fabricated to Section III of the ASME Boiler and Pressure Vessel Code (B&PVC). The design of the ISF Baskets complies with Section III. Their fabrication, however, utilizes an exception to Article NCA-8000, *Certificates, Nameplates, Code Symbol Stamping, and Data Reports.*

The fabrication of the ISF Baskets is in accordance with the ISF Facility Quality Program Plan (QPP) rather than B&PVC requirements. The B&PVC requires oversight by an Authorized Nuclear Inspector while the QPP allows FWENC quality assurance personnel to oversee fabrication. Because the ISF Baskets are not part of the SNF confinement boundary, this exception is considered acceptable.

Section 4.2 of the Proposed Technical Specifications identifies this deviation in fabrication requirements.

Certain lifting devices used to handle fuel in the FPA have been designed to handle fuel elements where a single failure proof load path is not possible. An example is a friction grip device used to handle Peach Bottom Core 2 fuels where the handling feature on the fuel element has been removed. These devices will not meet all requirements of ANSI N14.6, Section 4.3.5 (positive means of attachment to the fuel under load in all handling positions) and 7.1b (single failure proof design). The fuel handling operations in question will occur within the FPA confinement boundary, and the fuels will be packaged and stored in a manner consistent with NRC requirements for failed fuel. Under these conditions, dropping a fuel element will not result in unacceptable dose consequences during handling or storage. Therefore, these exceptions are considered acceptable.

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3.5 DECOMMISSIONING CONSIDERATIONS

The design and operation of the ISF Facility lends itself to decommissioning at the end of its mission. The decommissioning considerations incorporated into the facility design are summarized below. The first section provides design criteria for the SSCs not in the Storage Area. These SSCs will have a high utilization during the packaging phase of the project. The second section provides design criteria for the SSCs in the Storage Area. These SSCs have a 20-year (and potentially a second 20-year) exposure to the fuel in its dry storage condition.

The decommissioning plans for the ISF Facility are addressed in *Proposed Decommissioning Plan* (Ref. 3-49) that was prepared and submitted in accordance with 10 CFR 72.30 (Ref. 3-1).

3.5.1 Systems, Structures, and Components Not in the Storage Area

3.5.1.1 Transfer Cask

Upon completion of fuel transfer activities, the DOE transfer cask is returned to the DOE. In addition, the DOE reuses certain portions of its packaging. These portions are returned to the DOE in the DOE transfer cask when the empty cask is returned to the DOE. Hence, the DOE transfer cask and those returnable packaging components are not decommissioned as part of the ISF Facility.

3.5.1.2 Concrete Structures

The design of structural concrete incorporates features to facilitate decontamination and decommissioning. Examples include 1) concrete surfaces coated to minimize contamination, and 2) construction joints provided to aid in demolition of concrete elements.

3.5.1.3 Other Major SSCs Including Air Circulating and Filtration Systems

The cask receipt crane, cask trolley, and canister trolley are the major SSCs that are not in the Storage Area, FPA, Solid Waste Processing and Storage Area, or Liquid Waste Processing Area.

The cask receipt crane operates in an area of little potential for radioactive release, as the existing DOE transfer cask has been checked for external surface contamination before shipment by the DOE and remains bolted closed in the Cask Receipt Area. Therefore, the cask receipt crane will not require decontamination, and no special precautions in terms of materials or coatings are specified.

The other two pieces of equipment operate in an area where some potential for radioactive release may exist due to opening ports and opening the transfer cask. These SSCs will have coatings applied to the exposed metal surfaces that will aid in their surface decontamination. The level and duration of radiation exposure will not reach an activation level.

The HVAC systems provide air circulation and filtration. Except for through-wall penetrations, the HVAC system is not embedded into the concrete. The exhaust ductwork serving the operating gallery, workshop, CCA, Solid Waste Processing Area, Solid Waste Storage Area, Liquid Radioactive Waste Area, HEPA filter room, Transfer Tunnel, and decontamination areas are galvanized steel. Intermediate HEPA filters are provided in areas to protect supply and exhaust ductwork from contamination and to restrict backflow through the supply ducts should the room become pressurized. These HEPA filters are periodically replaced.

HVAC systems are designed to facilitate decontamination, satisfy ALARA requirements, and minimize the amount of radioactive waste generated during decommissioning. For example, any ducts that handle potentially contaminated air are fabricated of galvanized steel to minimize corrosion. They have welded seams and joints with gradual transitions to avoid pockets and crevices where contaminants can collect. HEPA filters in ducts that penetrate the primary confinement boundary reduce potential contamination in the downstream ductwork. The HVAC ductwork from the FPA to the final HEPA filters is of welded construction due to potential contamination. HEPA filters are installed on the exhaust ducts leaving the FPA. These filters act as pre-filters to protect the downstream ductwork from contamination. Filters are changed remotely using a master/slave manipulator or the power manipulator system, controlled from the operating gallery. Exhaust ducts are sized to maintain transport velocities sufficient to prevent particulate contaminants from settling out of the air stream. The amount of ductwork inside the primary confinement zone is minimized to reduce the quantity of potentially radioactive waste. Finally, HVAC components and systems are designed for accessibility and ease of maintenance.

3.5.1.4 Fuel Packaging Area

The SSCs inside the FPA are either uncoated stainless steel or coated/treated carbon steel. In both cases the steels will not be subjected to a level and duration of radiation to cause significant activation. The special lifting devices, worktable, and bench vessels have direct contact with the fuel. These items are coated or treated as practical to facilitate decontamination.

3.5.1.5 Radioactive Solid Waste Processing Area

The ISF Facility has an ongoing process for the removal of generated solid waste. The solid waste processing system safely handles, packages, and delivers waste to the INEEL RWMC. Handling and packaging activities may include size reduction, consolidation, and segregation of radioactive solid wastes. The INEEL's Reusable Property, Recyclable Materials, and Waste Acceptance Criteria (RRWAC) identify INEEL disposal packaging and shipping requirements. Solid waste is characterized and analyzed before requesting shipment to the RWMC. This is discussed in greater detail in Chapter 6.

The design of the solid waste processing system considers the feasibility of decontaminating components using conventional swabbing methods. Materials that absorb radioactive particles or make surface decontamination difficult have been avoided as much as possible. Equipment designs employ smooth, sloping surfaces and avoids crevices and other contamination traps.

3.5.1.6 Radioactive Liquid Waste Processing Area

The purpose of the liquid waste processing system is to safely handle, and minimize generation of liquid waste, and to ensure delivery of waste to an approved disposal facility. The system is discussed in greater detail in Chapter 6.

The design of the liquid waste processing system incorporates an operational philosophy that minimizes the generation of liquid waste by relying upon dry decontamination methods (e.g., vacuuming), swabbing and wiping down contaminated surfaces versus water sprays. This significantly reduces the size and scope of the liquid waste processing system. With the exception of through-wall penetrations, liquid waste piping will not be embedded into the concrete walls and floors of the facility, facilitating decontamination and removal.

3.5.1.7 Canister Closure Area

Any contamination that occurs in the CCA is minor and largely confined to the area of the CCA port. The area design utilizes coated components and smooth surfaces to facilitate contamination removal. During drying operations, HEPA filters in the vacuum drying system trap particulate material that may escape from the ISF canister.

3.5.1.8 Auxiliary Systems

With the exception of the HVAC system, the remaining auxiliary systems will remain radioactively clean.

3.5.2 Storage Area

3.5.2.1 Canister Handling Machine

Because the ISF canisters are welded and sealed, external contamination is unlikely and should not pose a problem for the CHM. Therefore, decommissioning will be a straightforward reversal of the initial erection and site assembly process using the same type of equipment. Some of this equipment will consist of maintenance tools; larger mobile crane equipment will be required to handle the bridge and trolley components during dismantling.

3.5.2.2 Concrete

The design of structural concrete incorporates features to facilitate decontamination and decommissioning. Examples include 1) concrete surfaces coated to minimize contamination, and 2) construction joints provided to aid in demolition of concrete elements.

3.5.2.3 ISF Canisters

The ultimate goal is to ship the loaded ISF canisters inside an NRC-approved transportation cask to the DOE permanent underground geologic repository. Hence, the ISF canisters and their internal contents are not part of the ISF Facility *Proposed Decommissioning Plan* (Ref. 3-49).

3.5.2.4 Storage Tubes

The possible (but unlikely) sources of contamination for the storage tubes include: 1) contamination from the outside surface of the ISF canister; and 2) radionuclide release from a leaking ISF canister. Both of these sources are expected to be at a level that can be readily decontaminated following shipment of the ISF canister to the DOE repository. The level and duration of radiation exposure may cause insignificant activation of the carbon steel storage tubes.

3.5.2.5 Auxiliary Systems

The auxiliary systems in the Storage Area will remain radioactively clean due to the contamination barriers provided by the ISF canister, storage tube assembly, and concrete of the storage vault. None of these auxiliary systems come into contact with the outside surface of the ISF canister, which is a potential source of surface contamination in the Storage Area.

3.6 SUMMARY OF DESIGN CRITERIA

The principal design criteria for the ISF Facility are summarized below.

Summary of Design Criteria

Design Parameter		Design Criteria
Maximum load capacity of cranes and trolley:		
	receipt crane	310,000 lb (see note below)
	FHM	10,000 lb (see note below)
	CHM	10,000 lb (see note below
	cask trolley	67,510 lb (Peach Bottom 2 cask)
	canister trolley	10,000 lb
Maximum load dimensions:		
	receipt crane	46.62 in dia. x 173.12 in high
	FHM	24 in dia. x 180 in high
	CHM	24 in dia. x 180 in high
	cask trolley	46.62 in dia. x 173.12 in high
	canister trolley	24 in dia. x 180 in high
Criticality factor		≤0.933
Maximum dose rates:		
	ISF Facility workers	1000 mrem/year
Ambient outside temperature:		
	average maximum	98°F
	average minimum	-26°F
Ambient humidity		0.00049-0.01346 lb water/lb dry air
Tornado parameters:	maximum velocity	200 mph
	rotational velocity	160 mph
	translational velocity	40 mph
	pressure drop	1.5 psi
Maximum wind		90 mph
Design earthquake peak acceleration		0.123 g horizontal at bedrock
Explosion peak overpressure		Not applicable
Flood elevation		4920.71 feet msl (NAVD 88)

Note: Load capacities for cranes are the rated capacities below the hook. Actual payload is reduced by any lifting devices below the hook.

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Table 3.1-1
Spent Fuel Physical Characteristics

Fuel Element Type		Dimensions (in)	Weight (lbs)
Peach Bottom	Core 1	3.5 X 144	90
	Core 1 with removal tool	3.642 X 146.3	100.2
	Core 2	3.5 X 126	84
TRIGA	Aluminum clad	1.47 X 28.37	6.4
	Aluminum clad (instrumented)	1.47 X 28.53	6.4[1]
	Stainless steel	1.478 X 28.94	7.5
	Stainless steel (instrumented)	1.478 X 29	7.5[1]
Shippingport	Reflector IV Module (intact/clamped)	140/141	4933-5200
	Reflector V Module (intact/clamped)	140/141	4028-4204
	Reflector Rods	0.832 X 114	16

1 Weight approximate

Table 3.1-2
Peach Bottom 1 Fuel Compact Initial Heavy Metal Loading
(Loading in grams per 3 in. of compact)

Compact Type:	**A**	**B**	**C**	**D**
Description:	**Standard**	**Heavy Rhodium**	**Light Rhodium**	**Heavy Thorium**
^{232}Th	52.10	52.10	52.10	115.36
^{234}U*	0.156	0.156	0.156	0.082
^{235}U	9.70	9.70	9.70	5.14
^{236}U*	0.052	0.052	0.052	0.028
^{238}U	0.505	0.505	0.505	0.268
^{103}Rh	0	1.028	0.342	0
Carbon	285.00	285.00	285.00	273.00

*^{234}U and ^{236}U loadings are not required. These are the maximum amounts expected in the fully enriched feed material.

Table 3.1-3
Peach Bottom 2 Fuel Compact Initial Heavy Metal Loading
(Loading in grams per 3 in. of compact)

Compact Type:	A	B	C	D
Description:	Standard	Heavy Rhodium	Light Rhodium	Heavy Thorium
^{232}Th	45.8	45.8	45.8	86.6
Uranium (93% enriched)	8.32	8.32	8.32	4.69
Rhodium	0	1.03	0.342	0

Table 3.1-4
Peach Bottom Fuel Element Characteristics

Fuel Element Type	Description	Spine	Compact Location and Type[1]		
			Upper 9 inches	Middle 54 inches	Lower 27 inches
1	Heavy rhodium	Solid graphite	A	B	A
2	Light rhodium	Solid graphite	A	C	A
3	Light rhodium with burnable poison	Hollow with poison compacts	A	C	A
4	Heavy thorium, light uranium	Solid graphite	D	D	D

1 Compact types are described in Tables 3.1-2 and 3.1.3.

Table 3.2-1
Design Basis Tornado Missiles

Missile	Mass (lb)	Dimensions	Velocity (ft/sec)
A. Wooden Plank	115	3.62 in x 11.38 in x 12 ft	190
B. 6-inch Sch 40 Pipe	287	6.62 in D x 15 ft	33
C. 1-inch Steel Rod	9	1 in D x 3 ft	26

Vertical velocities of 70% of the postulated horizontal velocities are used except for Missile C, which is used to test barrier openings, and is assumed to have the same velocity in all directions. Missiles A, B, and C are considered at all elevations of the facility structures as specified in NUREG-0800.

Table 3.2-2
Damping Values
(Percent of Critical Damping)

Structure or Component	**Design Earthquake**[1]
Equipment and large-diameter piping systems, pipe diameter greater than 12 in.	3
Small-diameter piping systems, diameter equal or less than 12 in.	2
Welded steel structures, cask trolley, canister trolley, storage tubes	4
Bolted structures, Cask Receipt Area hoist, CHM, FHM	7
Reinforced-concrete structures	7
Soil	5[2]

1 The allowable stress levels for the design condition that includes design earthquake are specified in the applicable codes for the respective structures or equipment corresponding to the accident condition.

2 The damping value indicated is the composite damping used in the soil-structure interaction.

Table 3.3-1
Radioactive Material Confinement Barriers

1.	DOE transfer cask(s) and fuel containers
2.	Fuel Packaging Area confinement boundary (including vent system HEPA filters, through-wall penetrations, shield plugs, concrete walls, shield windows, flexible seal between underside of cask port and cask, inflatable seal between underside of canister port and ISF canister)
3.	Lower subassembly of an ISF canister, basket, and shield plug
4.	Final closure welds and vacuumed dried, helium backfilled, and helium leak tested ISF canister
5.	Closed (bolted closure with two seals), vacuum purged, helium backfilled, and helium leak tested storage tube and ISF canister

Table 3.3-2
Criteria for the Design of Ventilation and Off-Gas Systems for Normal and Off-Normal Conditions

Criteria	Existing DOE Transfer Cask	Fuel Packaging Area	Unsealed ISF Canister	Sealed ISF Canister	Sealed ISF Canister in Sealed Storage Tube
A. Airflow patterns and velocity with respect to contamination control	Cask Receipt Area (Zone 3) and Transfer Tunnel (Zone 2) are in use Cask is closed during normal and off-normal conditions Cask Receipt Area is a radiologically clean area	FPA (Zone 1), FHM Maintenance Area (Zone 1), and HEPA filter room (Zone 2) are in use. The FPA is a primary contamination control zone. The room pressures in this zone will be maintained at the maximum negative values with respect to atmosphere so the airflow will always be inward towards the contamination enclosure.	Transfer Tunnel and CCA are in use (both are in zone 2).	Transfer Tunnel and CCA (both are in Zone 2) and Storage Area (Zone 3) are in use. ISF canister is sealed during normal and off-normal conditions.	Storage Area (Zone 3) is in use. The ISF canisters and storage tubes are each sealed. Storage Area is a radiologically clean area.
B. Minimum negative pressures at key points in the system to maintain proper flow control	Cask Receipt Area operates at atmospheric pressure	FPA room pressure is (-) 1.10 inch of water. FHM Area pressure is (-) 1.00 inch of water. During normal operations this is an unoccupied area.	Transfer Tunnel room pressure is (-) 0.40 inch of water. CCA room pressure is (-) 0.15 inch of water. These areas are provided with sufficient outside air to dilute airborne radionuclide concentrations and to maintain the prescribed room pressures.	Transfer Tunnel and CCA room pressures are not design criteria for this operation because the ISF canister is sealed.	Storage Area operates at atmospheric pressure.
C. Interaction of off-gas systems with ventilation systems	No interaction with an off-gas system and the ventilation system	Airflow through at least two sets of HEPA filters then to exhaust stack	Airflow through at least two sets of HEPA filters then to exhaust stack	No interaction with an off-gas system and the ventilation system.	No interaction with an off-gas system and the ventilation system.
D. Minimum filter performance with respect to particulate removal efficiency and maximum pressure drop	No filters required	Roughing filters and intermediate filters in FPA Intermediate filters between roughing filters and final filters. Final filters in HEPA filter room Fabric filter removal factor: 0.1 HEPA filter removal factor: 0.01 Maximum HEPA d/p: 4 in wg	Roughing filters inside CCA for weld fumes Final filters in HEPA filter room Fabric filter removal factor: 0.1 HEPA filter removal factor: 0.01 Maximum HEPA d/p: 4 in wg	No filters required	No filters required

Table 3.3-2
Criteria for the Design of Ventilation and Off-Gas Systems for Normal and Off-Normal Conditions

Criteria	Existing DOE Transfer Cask	Fuel Packaging Area	Unsealed ISF Canister	Sealed ISF Canister	Sealed ISF Canister in Sealed Storage Tube
E. Minimum performance of other radioactivity removal equipment	No other radioactivity removal equipment	Backdraft dampers, barometric dampers, and HEPA filters are utilized whenever necessary to prevent flow reversal due to accidental room pressurization.	Backdraft dampers, barometric dampers, and HEPA filters are utilized whenever necessary to prevent flow reversal due to accidental room pressurization.	No other radioactivity removal equipment	No other radioactivity removal equipment
F. Minimum performance of dampers and instrumented controls	No dampers or other instrumented controls	Supply dampers: Commercial quality (Class D) construction. Exhaust dampers: industrial quality (Class C) construction Primary HEPA isolation dampers: ASME N509 (Class A, group 1) construction.	No dampers or other instrumented controls	No dampers or other instrumented controls	Fixed louvers located on the exterior walls No dampers or other instrumented controls

Table 3.3-3
Key Equipment Selected to Provide Protection to the Spent Nuclear Fuel

Equipment Name	Key Equipment Items	Key Design Criteria
Existing DOE transfer cask (Use of Peach Bottom cask)	Cask	Design criteria pertaining to the DOE transfer cask are described in Appendix A.
	Trunnions	See Appendix A.
	O-rings	See Appendix A.
Cask receipt crane	Crane	NUREG-0554, *Single-Failure-Proof Cranes at Nuclear Power Plants*; CMAA-70
	Lifting devices	ANSI N14.6
Cask trolley	Trolley	NUREG-0554, *Single-Failure-Proof Cranes at Nuclear Power Plants*; CMAA-70
Fuel handling machine	Crane	NUREG-0554, *Single-Failure-Proof Cranes at Nuclear Power Plants*; CMAA-70
	Lifting devices	ANSI N14.6 (see note below)
ISF canisters, baskets, and other internal components (see note below)	Baskets	ASME Section III, Division 1, Subsection NG
	Shield plug	ASME Section III, Division 1, Subsection NF
	Impact plates	ASME Section III, Division 1, Subsection NF
	Canister	ASME Section III, Division 1, Subsection NB
	Lifting attachments	ANSI N14.6
Canister trolley	Trolley	NUREG-0554, *Single-Failure-Proof Cranes at Nuclear Power Plants* - CMAA-70
	Jacking system	ANSI N14.6
Canister handling machine	Crane	NUREG-0554, *Single-Failure-Proof Cranes at Nuclear Power Plants* - CMAA-70
	Lifting devices	ANSI N14.6
Storage tube	Two seal rings for bolted closure lid	ANSI N14.5
	Storage tube	ASME Section III, Division 1, Subsection NC
Concrete storage vault	Storage vault	ACI 349

Note: Due to the physical configuration of some of the fuels to be handled in the FPA, not all lifting devices will meet all applicable requirements of ANSI N14.6. Exceptions to certain fabrication requirements are taken for the ISF baskets. See Section 3.4 for further discussion.

Table 3.3-4
Instrumentation Requirements to Support Key Equipment

Equipment Name	Key Equipment Items	Instrumentation Required	Design Criteria Philosophy
Existing DOE transfer cask (use of Peach Bottom cask)	Cask	None	N/A
	Trunnions	None	N/A
	O-rings	None	N/A
Cask receipt crane	Crane	Yes	Abort lift if lifting equipment is trapped or snagged Apply brakes on loss of power Malfunction protection provided to meet NUREG 0554 and CMAA 70 Safety related signals will be derived from hard wired limit switch signals Positive break latching emergency stop button provided at strategic positions hard wired to interface relays and control contactors Seismic switch interrupts power during a seismic event
	Lifting devices	None	N/A
Cask trolley	Trolley	Yes	Safety related interlock signals hardwired from initiating device Positive break latching emergency stop button provided at strategic positions hard wired to interface relays and control contactors Seismic switch interrupts power during a seismic event
Fuel handling machine	Crane	Yes	Set drum flange brake on failed drum or shaft or failed hoist motor, brake or gear reducer Safety related signal derived from hard wired limit switch signals Positive break latching emergency stop button provided at strategic positions hard wired to interface relays and control contactors Seismic switch interrupts power during a seismic event
	Lifting devices	None	N/A

Table 3.3-4
Instrumentation Requirements to Support Key Equipment

Equipment Name	Key Equipment Items	Instrumentation Required	Design Criteria Philosophy
ISF canisters, baskets, and other internal components	Baskets	None	N/A
	Shield plug	None	N/A
	Impact plates	None	N/A
	Canister	None	N/A
	Lifting attachments	None	N/A
Canister trolley	Trolley	Yes	Same as cask trolley
	Jacking system	Yes	Prevent inadvertent jacking system initiation Safety related interlock signals hardwired from initiating device Positive break latching emergency stop button provided at strategic positions hard wired to interface relays and control contactors Seismic switch interrupts power during a seismic event
Canister handling machine	Crane	Yes	Prevent raising canister hoist in certain configurations Prevent lowering canister hoist in certain configurations Prevent turret rotating with turret locking pin disengaged Prevent grapple jaws from opening in unsafe conditions Safety related signals derived from hard wired signals Positive break latching emergency stop button provided at strategic positions hard wired to interface relays and control contactors Seismic switch interrupts power during a seismic event
	Lifting devices	None	N/A
Storage tube	Two seal rings for bolted closure lid	None	N/A
	Storage tube	None	N/A
Concrete storage vault	Storage vault	None	N/A

Table 3.3-5
Control Methods for Prevention of Criticality

Control Methods for Prevention of Criticality	Fuel in Existing DOE Transfer Cask	Fuel in FPA	Waste from Fuel Elements in the FPA	Fuel in ISF Canister	Loaded ISF Canister in Storage Tube and Storage Vault
Limitation on the amount of Fissile Material					
No mixing of fuel types	X	X	X	X	X
Number of fuel elements	X	X	X	X	X
Mass of loose fissile material	X	See *Waste from Fuel Elements in the FPA*	X	X	X
Engineered Safety Features					
Physical separation of sets of fuel elements by engineered features	X	X	Not applicable	X	X
Geometric control provided by basket structure or work station vessel	X	X	X	X	X
Use of burnup credit	Not used	Not used	Not used	Not used	Not used
Use of burnable or fixed neutron absorbers (poisons)	Not used	Not used	Not used	Not used	Not used

X = Design Consideration

Table 3.3-6
Radiological Protection Design Criteria

Location	Normal and Off-Normal Conditions	Accident Conditions
Restricted Area	As Low As Is Reasonably Achievable (ALARA) in accordance with 10 CFR 72.126(d) 5,000 mrem/yr TEDE in accordance with 10 CFR 20.1201, *Occupational Dose Limits for Adults* 1,000 mrem/yr TEDE in accordance with ISF Facility administrative control limits	ALARA in accordance with 10 CFR 72.126(d)
Controlled Area	100 mrem/yr TEDE in accordance with 10 CFR 20.1301, *Dose Limits for Individual Members of the Public*	5,000 mrem TEDE for any design basis accident in accordance with 10 CFR 72.106(b)
Outside of Controlled Area	25 mrem/yr TEDE in accordance with 10 CFR 72.104(a)	5,000 mrem TEDE for any design basis accident in accordance with 10 CFR 72.106(b)

Table 3.3-7
ISFSI Fuel Handling and Storage Systems Summary

Key equipment name	Cooling Requirements for SNF	Onsite Movement Criticality Control	Contamination Control	Handling Damaged Fuel or Waste Containers
Existing DOE transfer cask (use of cask originally designed for transport of Peach Bottom fuel)	Temperatures of various existing DOE transfer casks components are well below material limits when shipping any of the fuel types defined in Section 3.1. Appendix A provides additional details.	Criticality control by one or more of the following 1) amount of fissile material in cask, 2) geometric control provided by basket designs, 3) no credible source of water intrusion. See Appendix A for additional details.	Outside of transfer cask is decontaminated by DOE before shipping to INEEL ISF Facility. Unloaded transfer cask is checked for outside surface contamination before sending back to the DOE.	Baskets, liners, containers, buckets accommodate handling and storage of damaged fuel.
Cask receipt crane	Does not affect cooling requirements of fuel	See Table 3.3-3 for design criteria used to eliminate cask drop or tip-over	Not a source of contamination Contact with external surfaces of transfer cask is not an expected source of contamination to the cask receipt crane	Designed to lift up to 310,000-lb cask. Cask may contain damaged fuel.
Cask trolley	Does not affect cooling requirements of fuel	See Table 3.3-3 for design criteria used to eliminate cask drop or tip-over	Not a source of contamination Contact with external surfaces of transfer cask is not an expected source of contamination to the cask trolley	Designed to transport up to 67,510-lb cask. Cask may contain damaged fuel.
Fuel handling machine and worktable	Does not affect cooling requirements of fuel	See Table 3.3-3 for design criteria used to eliminate dropping of SNF	Not a source of contamination Contact with spent nuclear fuel is an expected source of contamination	Special lifting devices designed for use with various fuel types. Worktable designed to handle and repackage damaged spent nuclear fuel.
ISF canisters, baskets, and other internal components	Temperatures of various ISF canister components are well below ASME Section III limits.	Criticality control by combination of; 1) amount of fissile material in cask, 2) geometric control provided by basket designs, and/or 3) no credible source of water.	Canister is never placed inside the FPA Loaded ISF canister is checked for outside surface contamination before placement into the storage tube.	ISF basket design accommodates handling of damaged fuel.
Canister trolley	Canister cask causes slight temperature increase of fuel in the loaded ISF canister. Temperatures of various ISF canister components are well below ASME Section III limits.	See Table 3.3-3 for design criteria used to eliminate canister drop or tip-over	Not a source of contamination Contact with external surfaces of ISF canister is a potential source of localized contamination to the canister trolley	Designed to transport up to 10,000-lb ISF canister. ISF canister can contain damaged fuel.

Table 3.3-7
ISFSI Fuel Handling and Storage Systems Summary

Key equipment name	Cooling Requirements for SNF	Onsite Movement Criticality Control	Contamination Control	Handling Damaged Fuel or Waste Containers
Canister handling machine	ISF canister inside the turret causes slight temperature increase of fuel in the loaded ISF canister. Temperatures of various ISF canister components are well below ASME Section III limits.	See Table 3.3-3 for design criteria used to eliminate canister drop or tip-over	Not a source of contamination Contact with external surfaces of ISF canister is a possible, but unlikely source of localized contamination to the CHM	Designed to transport up to 10,000-lbs ISF canister. ISF canister can contain damaged fuel.
Storage tube	ISF canister inside the storage tube causes slight temperature increase of fuel in the loaded ISF canister. Temperatures of various ISF canister components and storage tube components are well below ASME Section III limits.	Spacing between storage tubes is such that neutronic interaction among ISF canisters of SNF results in keff being maintained below the defined acceptance criteria of 0.95 for all combinations of loading patterns.	Not a source of contamination Contact with external surfaces of contaminated ISF canister is a possible, but unlikely source of localized contamination to the inside surface of the storage tube. External surface of storage tube is not exposed to any source of contamination.	Designed to store ISF canister. ISF canister can contain damaged fuel.
Concrete storage vault	Provides a passive heat removal system for the decay heat. Temperatures of concrete are within ACI recommended temperature limits.	Spacing between storage tubes is such that neutronic interaction among ISF canisters of SNF results in keff being maintained below the defined acceptance criteria of 0.95 for all combinations of loading patterns.	Not a source of contamination nor expected to be in contact with contaminated equipment	Designed to maintain storage tubes in a vertical position.

Table 3.3-8
Radioactive Waste Treatment Criteria and Implementation Method

	Implementation Method		
Waste Treatment Criteria	**Gaseous Waste**	**Liquid Waste**	**Solid Waste**
Reduction in volume	Gaseous waste inside the FPA, Transfer Tunnel, and CCA passes through filters to concentrate the airborne particulate.	Limited sources of water in radioactivity contaminated areas.	Contaminated solid materials are cut or compressed to reduce their volume.
Control of releases of radioactive materials during treatment	Control of releases is provided by collection in filters and the welded construction of the HVAC ductwork.	Control of releases is provided by collection in filters, use of watertight piping and fittings, and storage tank.	Contamination level is checked and required decontamination is performed in the FPA. Both the FPA and Solid Waste Processing Area have HEPA filter systems.
Conversion to solid forms	Filters concentrate the airborne particulate.	Filters concentrate the particulate in the liquid.	Not applicable
Suitability of product containers for storage or shipment to a disposal or storage site	Contaminated filters are stored and shipped in drums that meet storage or shipment requirements.	Contaminated filters are stored and shipped in drums that meet storage or shipment requirements. Liquid waste is stored onsite in a tank meeting API codes and is transported offsite in DOT-approved tankers.	Contaminated materials are stored in drums, shielded drums, or a waste bin inside the Solid Waste Area. Storage containers meet INEEL's RRWAC before use.
Safe confinement during onsite storage	Filters are stored inside storage drums.	Liquid is stored in the liquid waste tank.	Solid waste is in the FPA, Solid Waste Processing Area, or in drums in the Solid Waste Storage Area.
Monitoring during onsite storage to demonstrate safe confinement	In-line and final filters have monitors associated with them.	Areas containing liquid waste have monitors.	Solid Waste Processing and Storage Areas and FPA have monitors.
Final decontamination, retrieval, and disposal of stored wastes during decommissioning	In-line and final filters are periodically replaced. Final decontamination, retrieval, and disposal of filters and HVAC ducts will take place during decommissioning.	Liquid waste tank is filtered periodically and disposed approximately once per year. Final decontamination, retrieval, and disposal of liquid waste tank and associated piping will take place during decommissioning.	Solid waste storage bin and storage barrels are periodically removed and replaced with empty containers. Final decontamination, retrieval, and disposal of the solid waste storage bin and storage barrels will take place during decommissioning.

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Table 3.4-1
SSCs Classified ITS

SSC	ITS Justification
Cask Receipt Area	
DOE Transfer cask(s) and fuel containers	The transfer cask and fuel containers prevent damage to spent fuel during transit from the DOE and while in the cask trolley.
Cask receipt crane	The cask receipt crane is used for receiving various transfer casks for transport to process or storage areas. The crane is a part of the load path for handling the transport cask loaded with SNF. Damage could result from a crane failure and subsequent cask drop.
Cask receipt crane lifting equipment	The lifting equipment is part of the cask receipt crane equipment and is used for receiving various transfer casks for transport to process or storage areas. The equipment is a part of the load path for handling the SNF container. Damage could result from a crane or associated equipment failure and subsequent cask drop.
Cask receipt crane supports	The cask receipt crane supports are part of the cask receipt crane system and are a part of the load path for handling the transport cask loaded with the SNF container. Damage to the SNF could result from a crane failure and subsequent drop.
Cask receipt area load-bearing structures/footings (hoist load path, canister and cask trolley rails)	The structures/footings provide a part of the load path when lifting the cask for transfer to and from the cask trolley using the cask receipt hoist. Failure of the structure or footings could result in a drop of the cask with the potential for damage to the SNF container.
Transfer Area	
Seismic switch	Many facility and process systems are designed to operate within safe envelopes and to shut down in the passive fail-safe mode. However, failure of the seismic switch could continue to allow power to be conducted to equipment items that are designed to fail safe but need to passively shut down during a seismic event. This could result in damage that could potentially impact the public health and safety risk.
Cask trolley (including support racks, ties, restraints, etc.)	The Cask trolley provides the mechanism along with the support hardware to ensure that the various transfer casks are in a stable configuration during transfer and that tip-over or other postulated accidents do not cause damage during transit.
Cask trolley rails and encasts	The Cask trolley, rails and encasts,.and trolley support hardware are all part of the equipment used to transfer casks to the storage or processing areas. This equipment ensures that casks are maintained in a stable configuration during transfer and that tip-over or other damage to the cask and subsequently to the spent fuel does not occur.
Canister trolley (including jacking system)	The Canister trolley lifts and positions canisters containing spent fuel at several stations within the Transfer Tunnel. Component failure could result in fuel damage.
Transfer Tunnel outer door	The outer door prevents damage to spent fuel by protecting the cask and canister trolleys from tornado wind and missile effects.
Transfer area structural concrete and confinement boundary	The reinforced concrete structure of the Transfer Area confines radioactive materials and provides the structure that supports the SNF lifting equipment. It is part of the load path and has functions required to prevent damage to the SNF during handling and storage. The confinement boundary structures for the processing areas of the facility confine radioactive materials to ensure no uncontrolled releases and therefore to ensure that there is no undue risk to the health and safety of the public.
FHM	The FHM is used for the manipulation of spent fuel within the FPA. A lifting component failure and subsequent drop could result in spent fuel damage.

Table 3.4-1
SSCs Classified ITS

SSC	ITS Justification
Inflatable seal (one each) 1) between underside of cask port and transfer cask, and 2) between underside of canister port and ISF canister	The inflatable port seals form a part of the FPA confinement boundary.
FHM lifting devises used for fuel handling	Selected FHM lifting devices are used for the transport of spent fuel in various configurations within the FPA. A lifting component failure and subsequent drop could result in spent fuel damage.
FHM rails and supports	The FHM rails and supports are used to transport spent fuel in various configurations within the FPA. The FHM, including its rails and supports, is part of the load path for the spent fuel. Component failure and a subsequent drop could result in fuel damage.
FPA shield windows	The shield windows form part of the confinement boundary for the spent fuel. Their proper functioning ensures that radioactive materials are contained and that radiation levels remain within acceptable and analyzed limits.
Master slave manipulators (MSM)	The through wall tube of the MSM is part of the confinement barrier of the FPA that prevents the release of radioactive materials.
Bench containment vessels	The bench containment vessels have structural integrity and criticality control functions that are relied upon to prevent damage to the SNF basket, and therefore the fuel, during design basis accidents that have the potential to affect the SNF geometry (including natural phenomena events).
FPA worktable	The worktable functions as part of the SNF load path. Failure of the lift components could cause fuel damage.
FPA monorail	The monorail provides additional capability for lifting the transfer cask lid and the shield plug in the FPA. It could also be used for lifting spent fuel in the FPA. Component failure could result in fuel damage.
Personnel shielded access door	The personnel shielded access door is part of the FPA wall. It provides a confinement and shielding function to provide assurance that radiation dose rates remain within acceptable and analyzed limits.
Encasts (SNF support – non Storage Area)	Some of the encasts in process areas other than the Storage Area provide wall linings, floor plates, or mounting points that support SNF or loaded SNF containers. Failure of these SSCs could result in damage to the SNF canister during handling and storage. These SSCs have structural integrity and geometry control functions that are necessary to provide reasonable assurance that the spent fuel can be processed safely.
Encasts (through confinement wall)	The encasts that penetrate the confinement walls of process areas are components of those confinement barriers and are necessary to provide reasonable assurance that the spent fuel can be repackaged without undue risk to the public.
Shield plugs (through confinement wall)	The shield plugs that penetrate the confinement walls of process areas are components of the confinement barrier during the processing of the SNF and are necessary to ensure that confinement is maintained.
FPA confinement wall service penetrations	The penetrations are part of the confinement boundary because they penetrate the wall of process area. Failure of the penetrations could result in a breach of the confinement wall and could impact the health and safety of the public.

Table 3.4-1
SSCs Classified ITS

SSC	ITS Justification
HVAC system	The system defines the ventilation zones and provides filtration of radioactive materials within the confinement boundary (FPA) to ensure that there is no undue risk to the public. Failure of the system or system components that define the confinement boundary could result in impact the health and safety risk of the public beyond analyzed and acceptable limits.
Storage Area	
Storage Area concrete vault structure	The concrete vault provides the structure that dictates, ensures, and maintains the geometry and condition of the fuel storage array. It protects the ISF canisters and storage tube assemblies during design basis events.
CHM	The CHM transports and positions canisters containing spent fuel within the Storage Area. Component failure could result in fuel damage.
CHM (rails and conductors)	Failure of the CHM rails or conductors could impair the ability of the CHM to perform its ITS functions or could result in the CHM damaging the spent fuel canister and subsequently the spent fuel confinement or configuration.
CHM grapple	The CHM grapple is part of the load path for handling the spent fuel canisters within the Storage Area. Failure of the CHM grapple could result in damage to the spent fuel canister and subsequently the spent fuel, resulting in a loss of confinement.
Charge face cover plate	The cover plates are the structural cover for the storage tubes providing missile protection for the tubes and shielding plugs and preserving the integrity of the spent fuel.
Storage tube assembly	The storage tube assembly provides the secondary confinement boundary and ensures an inert atmosphere to minimize corrosion.
Storage tube support stool	The support stool ensures that seismic and differential thermal movements do not introduce any axial loads in the storage tube that could damage the tube or the ISF canister within. It also provides axial support that aids in maintaining the tube and its enclosed SNF in a critically safe array.
Storage area fixed building ventilation	The Storage Area fixed building ventilation is a passive system required to maintain the Storage Area temperature sufficiently low to preclude damage to the storage structure or a stored canister.
ISF basket	The ISF basket provides orientation and structural support for spent fuel within the ISF canister. Damage to the basket could result in fuel damage and the failure to maintain a subcritical geometry.
ISF canister	The canister provides the primary confinement barrier to the release of radioactive material from the spent fuel.

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Figure 3.1-1
Peach Bottom Fuel Element

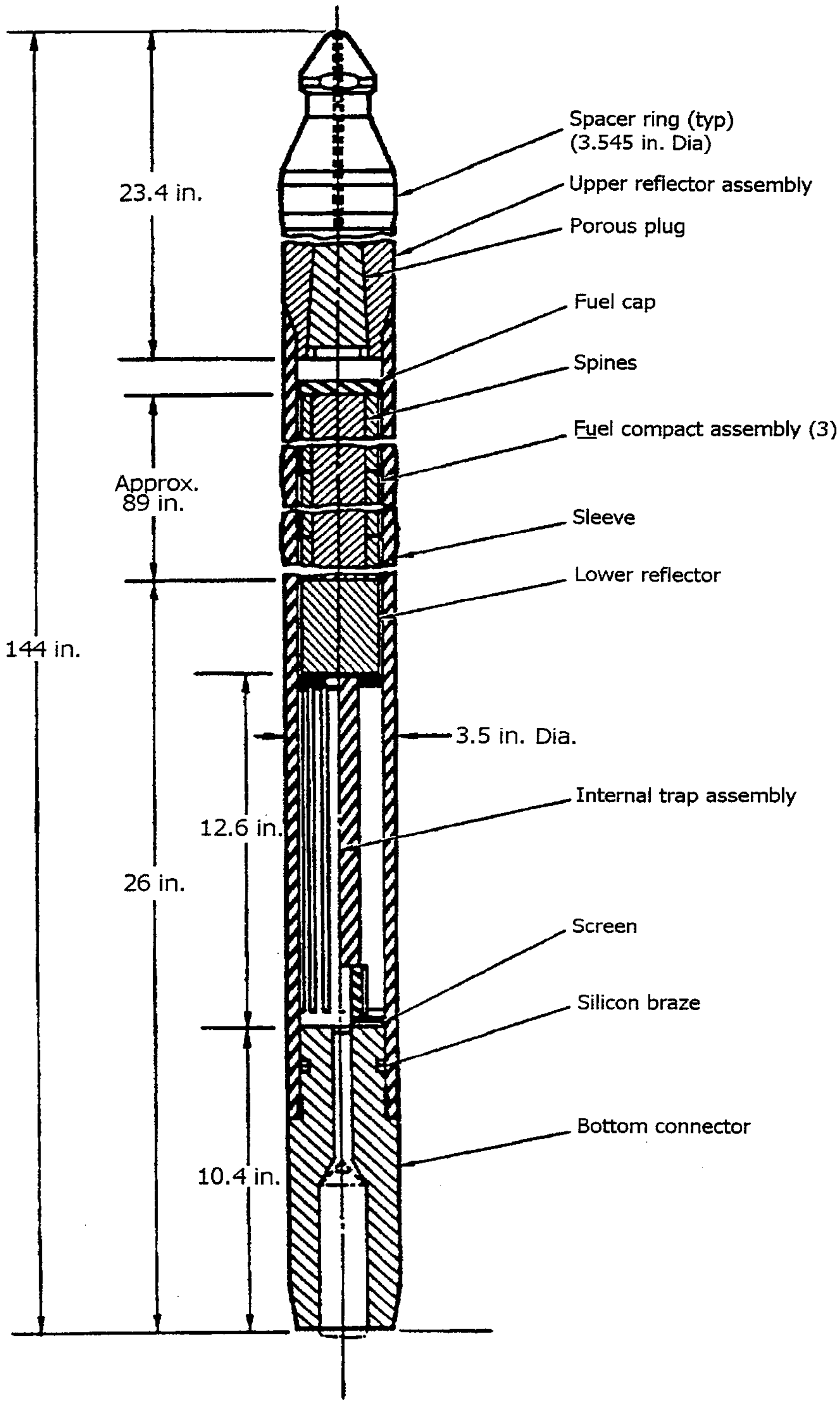


Figure 3.1-2
Peach Bottom Fuel Element with Removal Tool

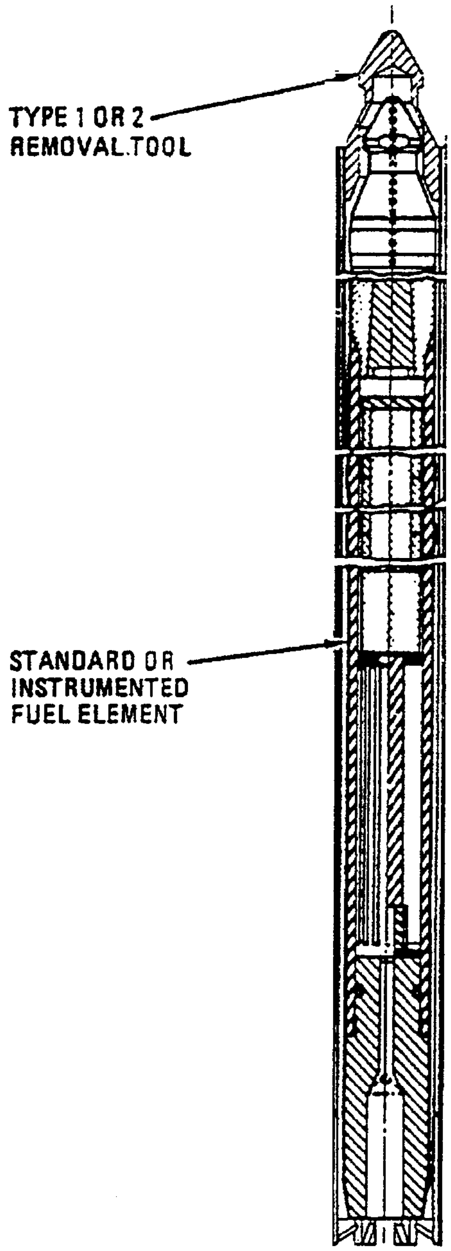


Figure 3.1-3
Intact Peach Bottom Element within Aluminum Canister

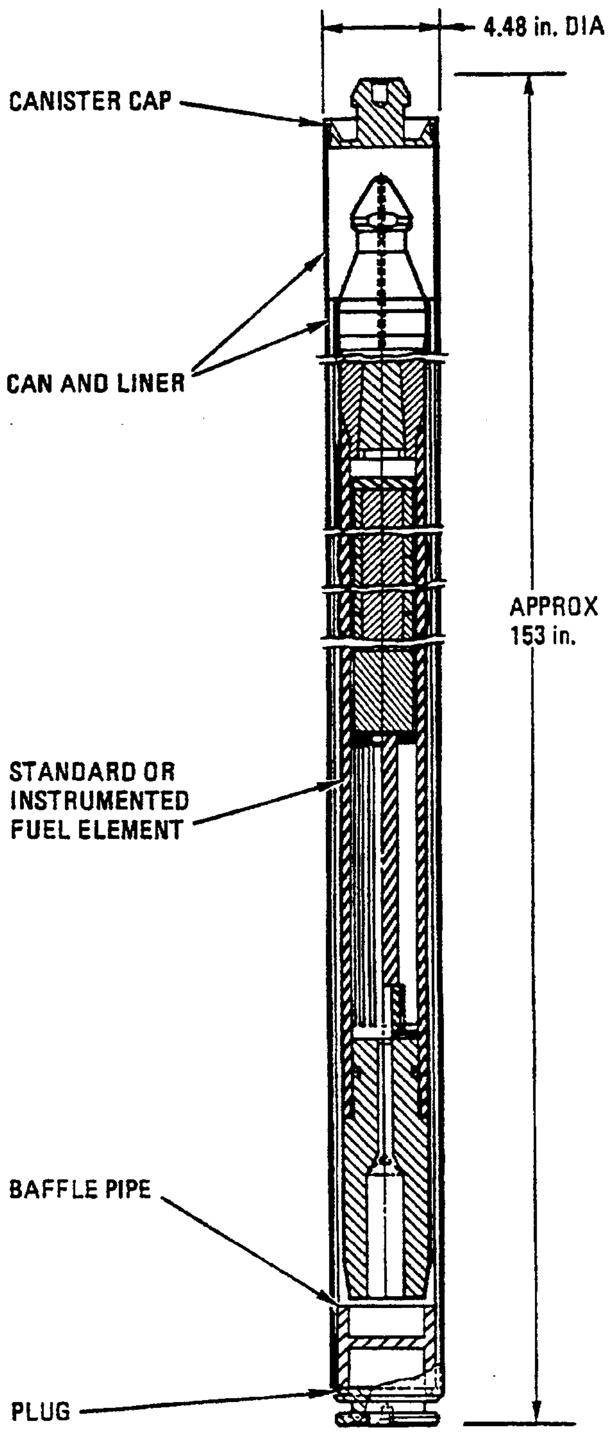


Figure 3.1-4
Peach Bottom Element and Removal Tool within Aluminum Canister

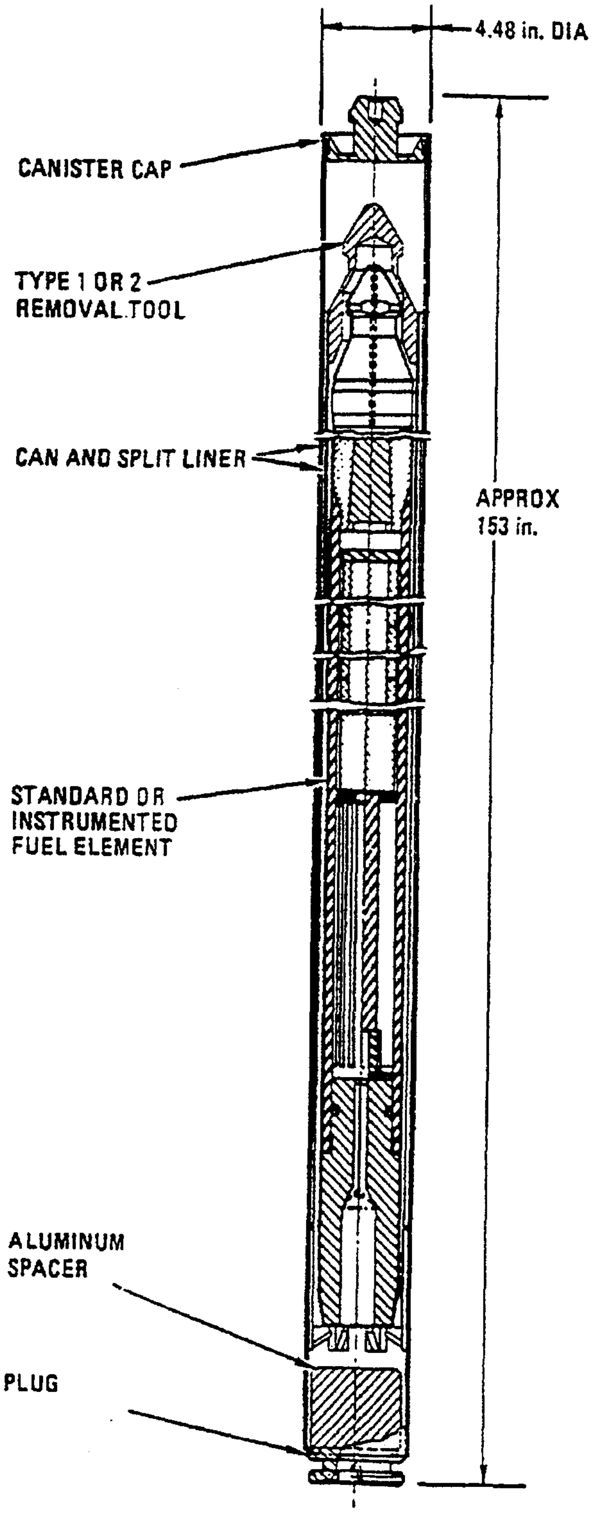


FIGURE 3.1-5
Peach Bottom Salvage Canister

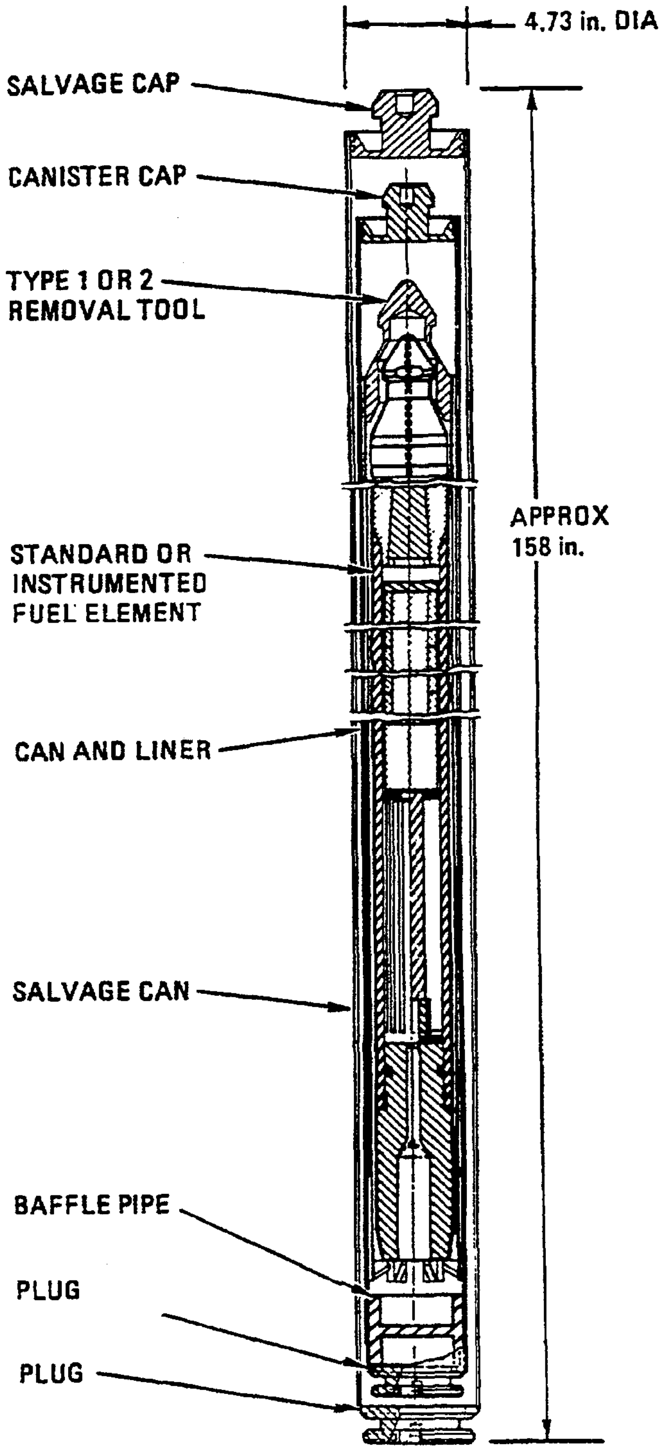


Figure 3.1-6
TRIGA Fuel Element

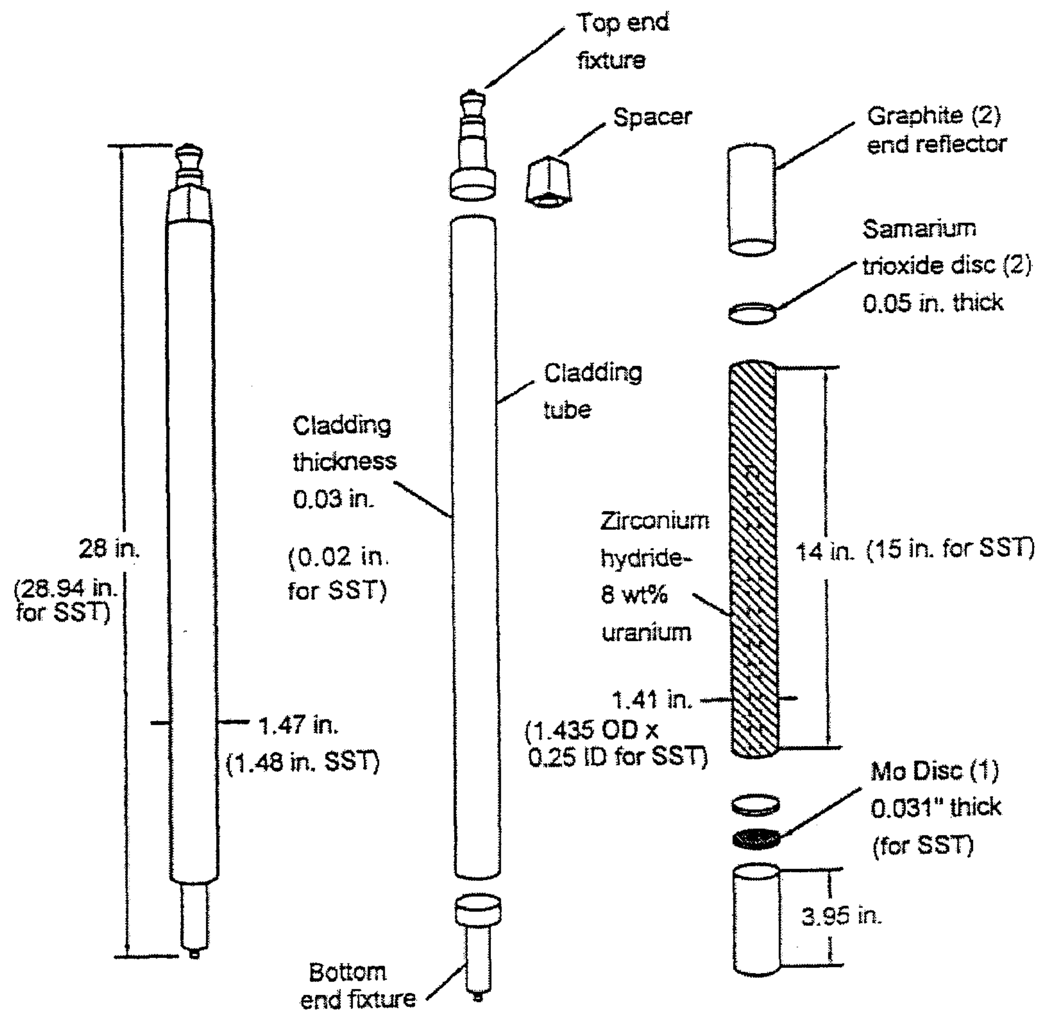


FIGURE 3.1-7
Shippingport Core Layout

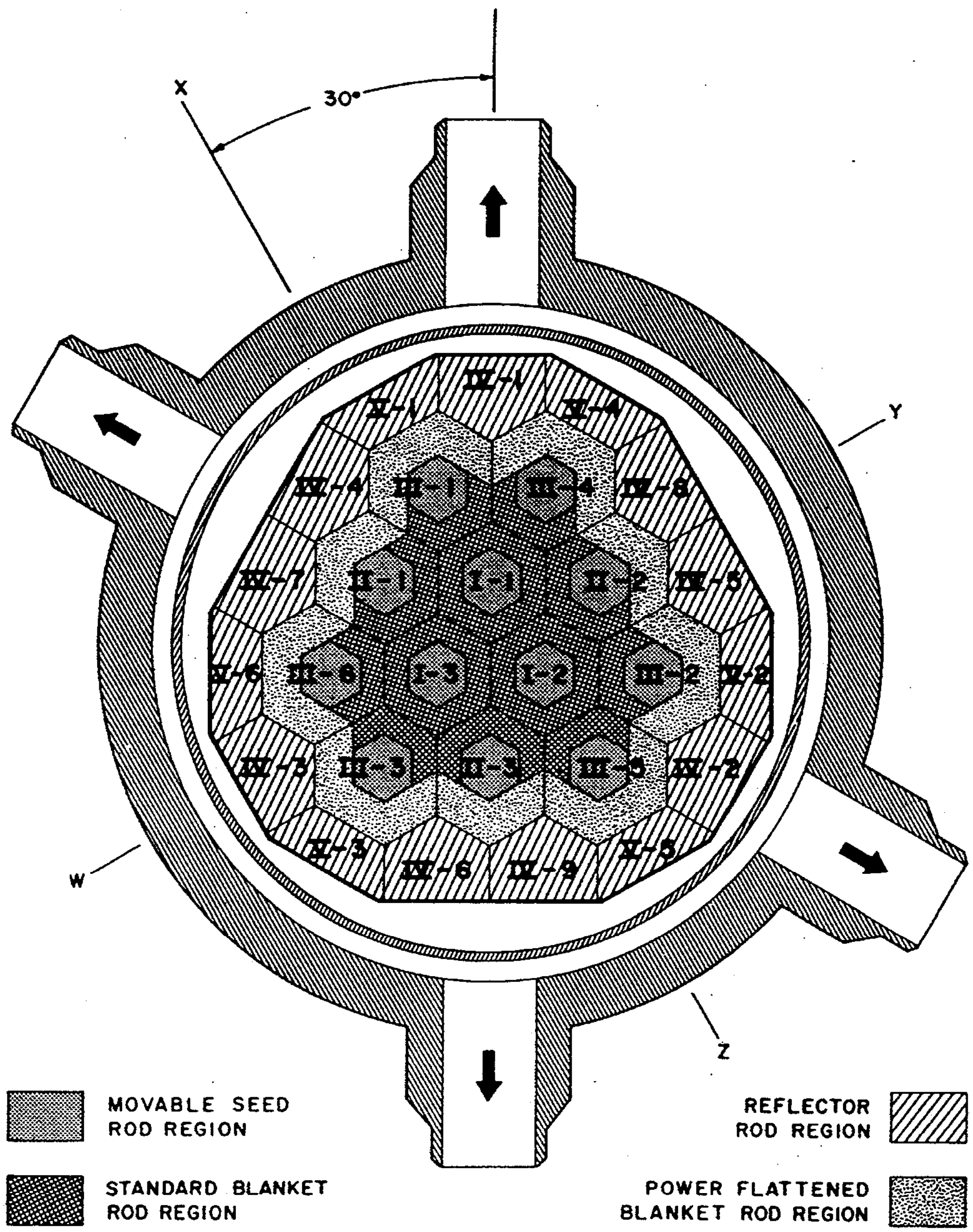
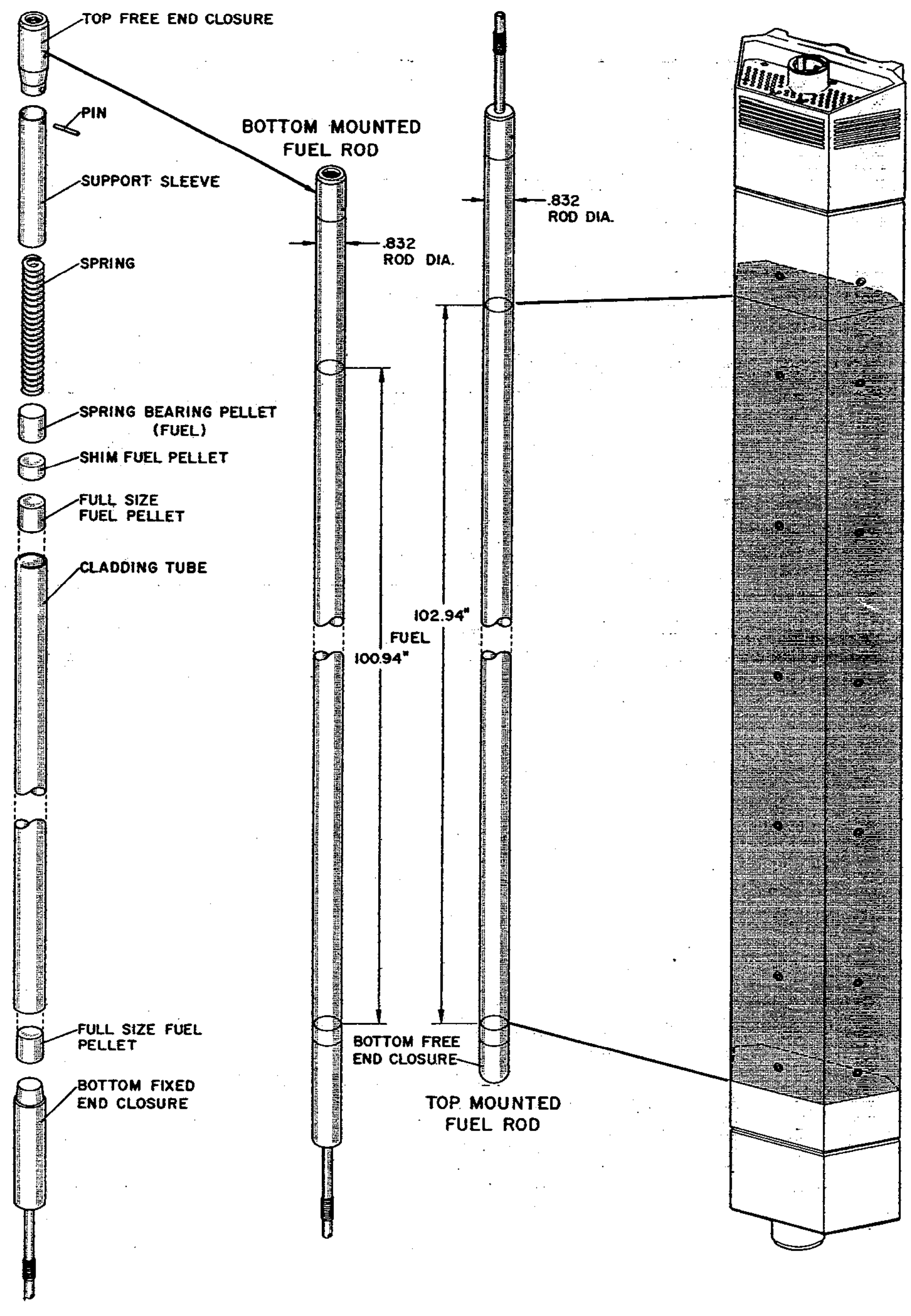


FIGURE 3.1-8
Shippingport Type V Reflector Module



WAPD-TM-1208/17

Figure 3.1-9
Peach Bottom 1 Decay Heat (Watts/Element)

1 Jul 97	1 Jul 00	1 Jul 04	1 Jul 10	1 Jul 20
5.494×10^{-2}	5.425×10^{-2}	5.329×10^{-2}	5.182×10^{-2}	4.934×10^{-2}

NOTE: The zero time corresponds to a starting date of 01 Jul 1996

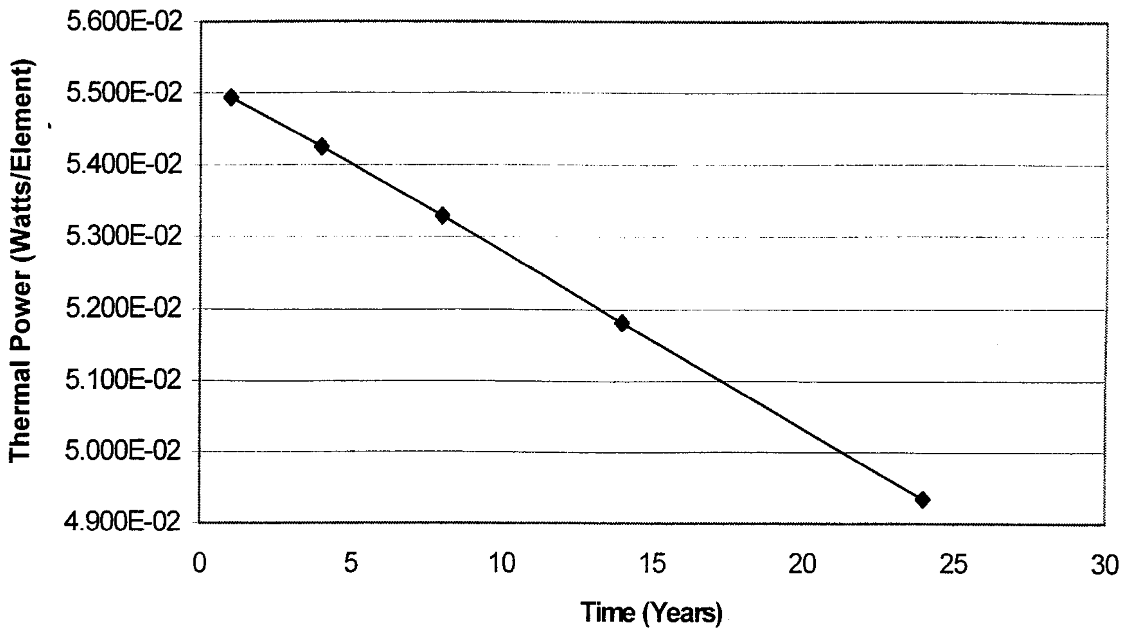


Figure 3.1-10
Peach Bottom 2 Decay Heat (Watts/Element)

1 Jul 03	1 Jul 04	1 Jul 07	1 Jul 10	1 Jul 20
3.346E+00	3.276E+00	3.075E+00	2.889E+00	2.357E+00

NOTE: The zero time corresponds to a starting date of 01 Jul 2002

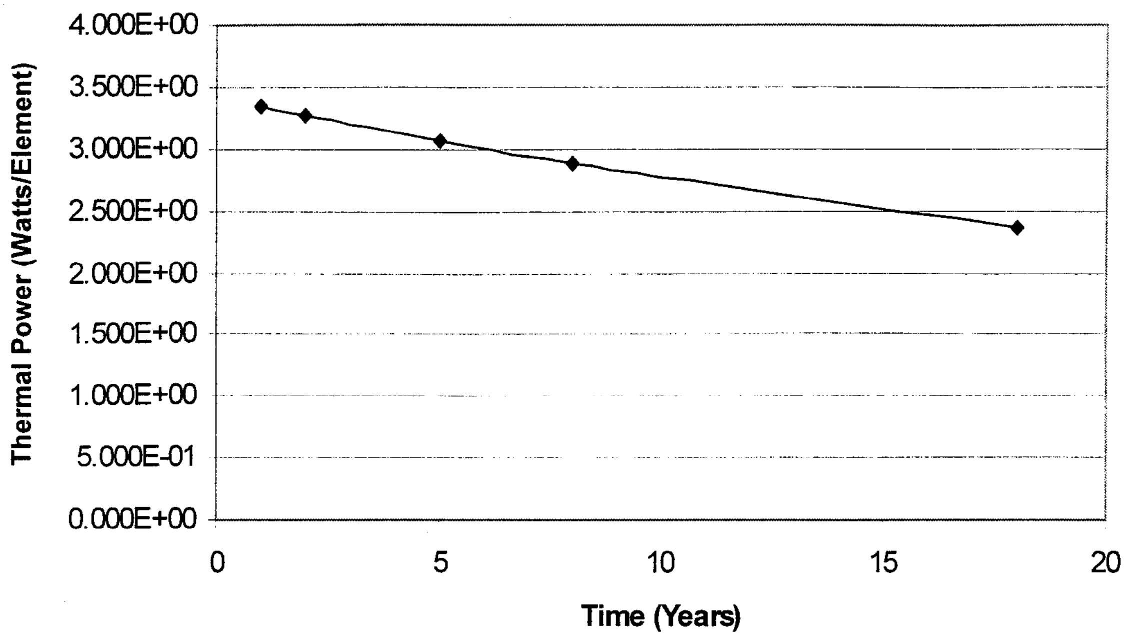


Figure 3.1-11
Shippingport Type IV Decay Heat (Watts/Module)

1 Jul 03	1 Jul 04	1 Jul 07	1 Jul 10	1 Jul 20
1.000E+01	9.809E+00	9.260E+00	8.755E+00	7.316E+00

NOTE: The zero time corresponds to a starting date of 01 Jul 2002

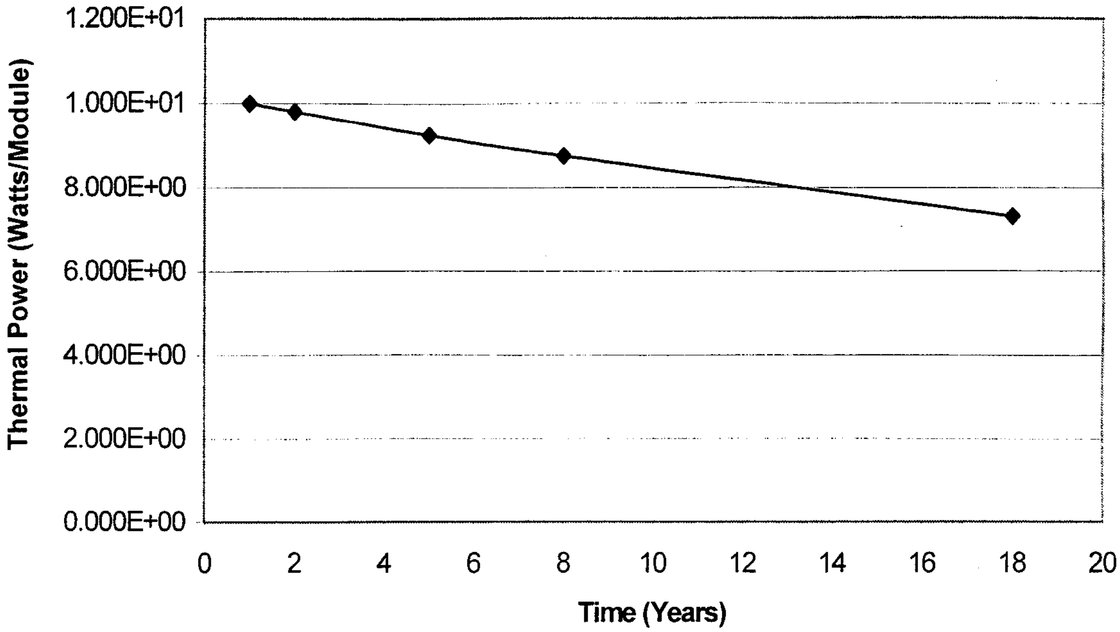


Figure 3.1-12
Shippingport Type V Decay Heat (Watts/Module)

1 Jul 03	1 Jul 04	1 Jul 07	1 Jul 10	1 Jul 20
7.282E+00	7.142E+00	6.742E+00	6.374E+00	5.326E+00

NOTE: The zero time corresponds to a starting date of 01 Jul 2002

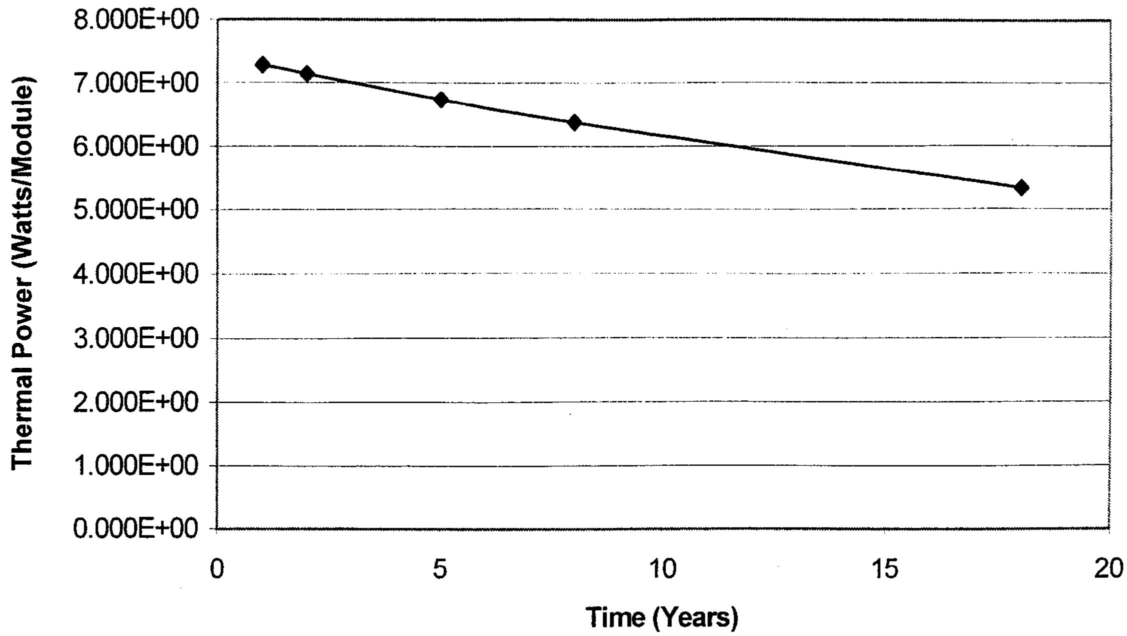


Figure 3.1-13
Average TRIGA Fuel Element Decay Heat (Watts/Element)

1 Jan 99	1 Jan 01	1 Jul 04	1 Jul 10	1 Jul 20
1.339E+00	5.500E-01	3.265E-01	2.266E-01	1.524E-01

NOTE: The zero time corresponds to a starting date of 01 Jan 1998

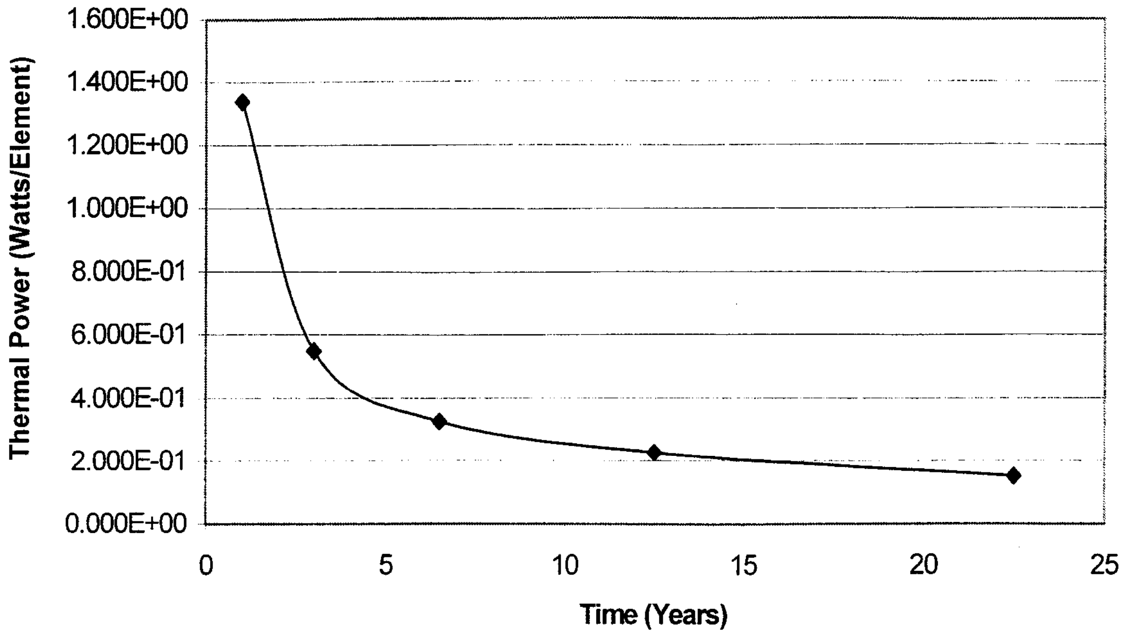
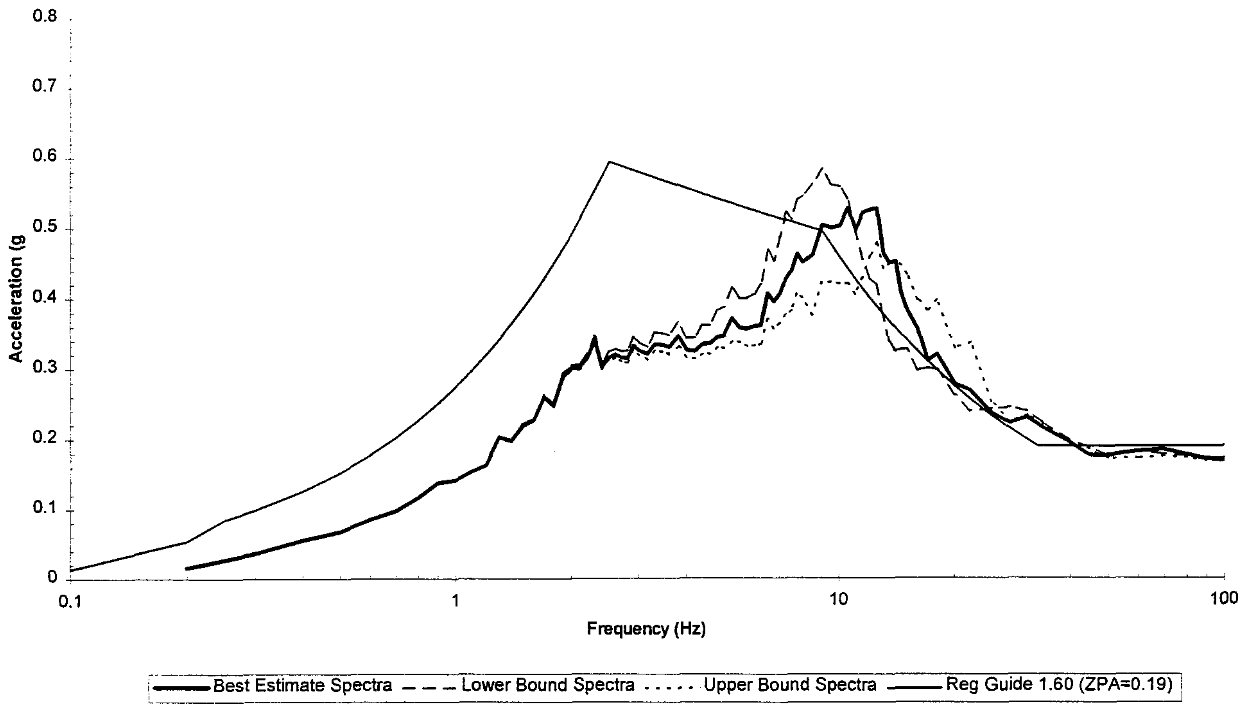
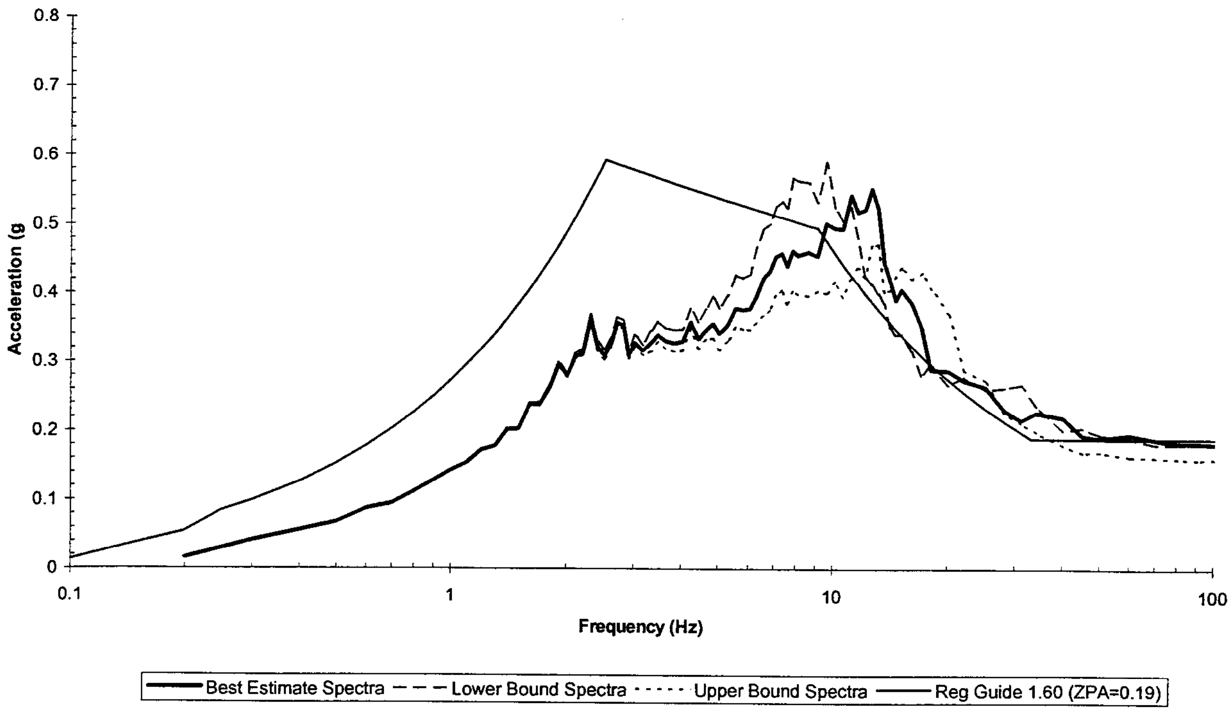


Figure 3.2-1
ISF Ground Surface Response Spectra
Horizontal 1 Direction–5% Damping



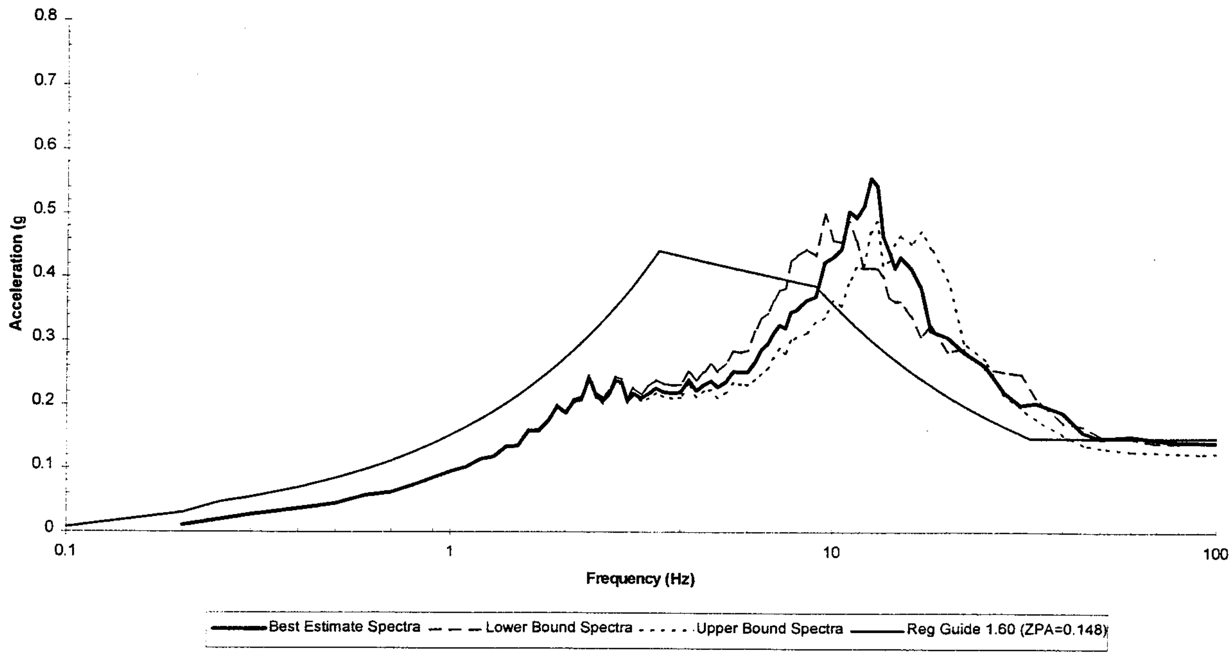
ISF-FW-RPT-0052; Fig 2

Figure 3.2-2
ISF Ground Surface Response Spectra
Horizontal 2 Direction–5% Damping



ISF-FW-RPT-0052; Fig 3

Figure 3.2-3
ISF Ground Surface Response Spectra
Vertical Direction–5% Damping



ISF-FW-RPT-0052; Fig 4

Figure 3.2-4
Cask Receipt Area SSI Model

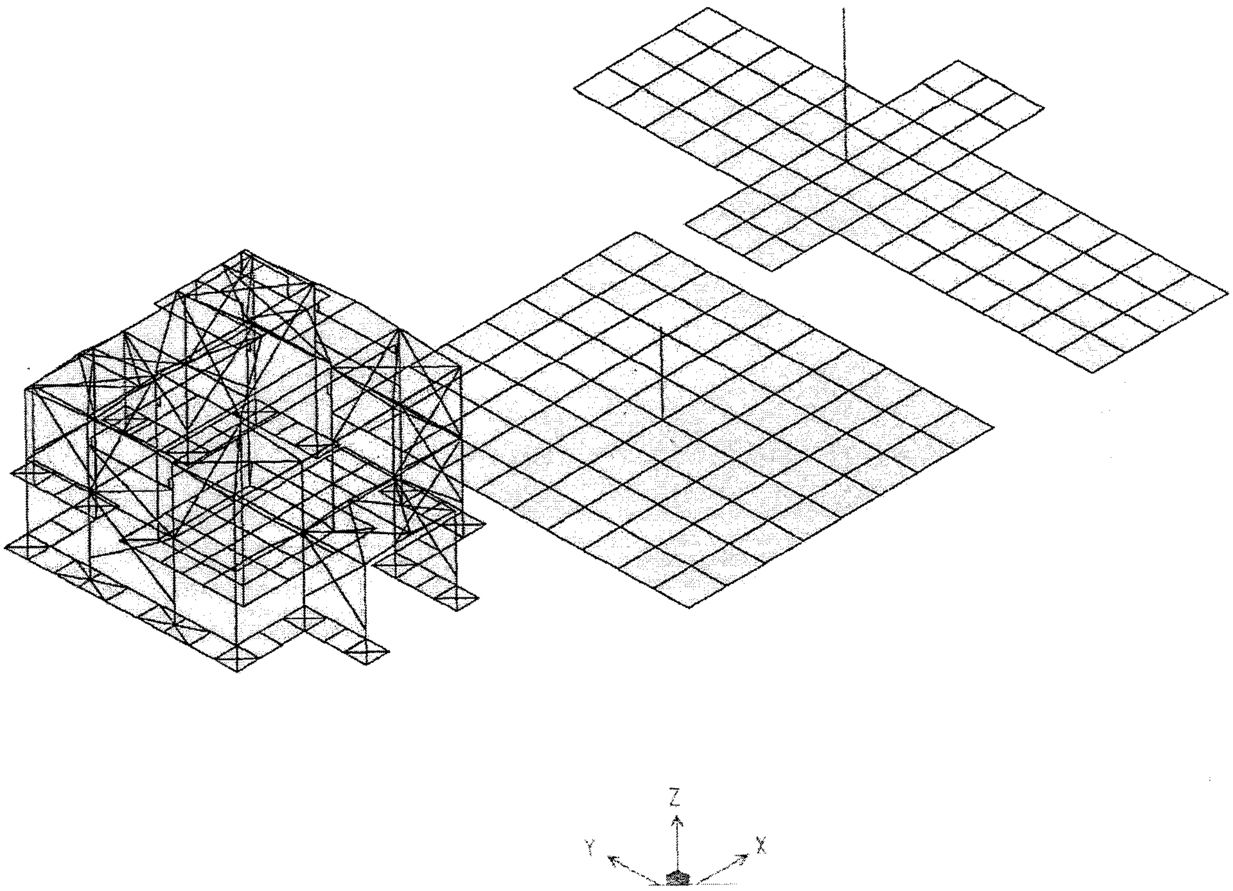


Figure 3.2-5
Storage Area SSI Model

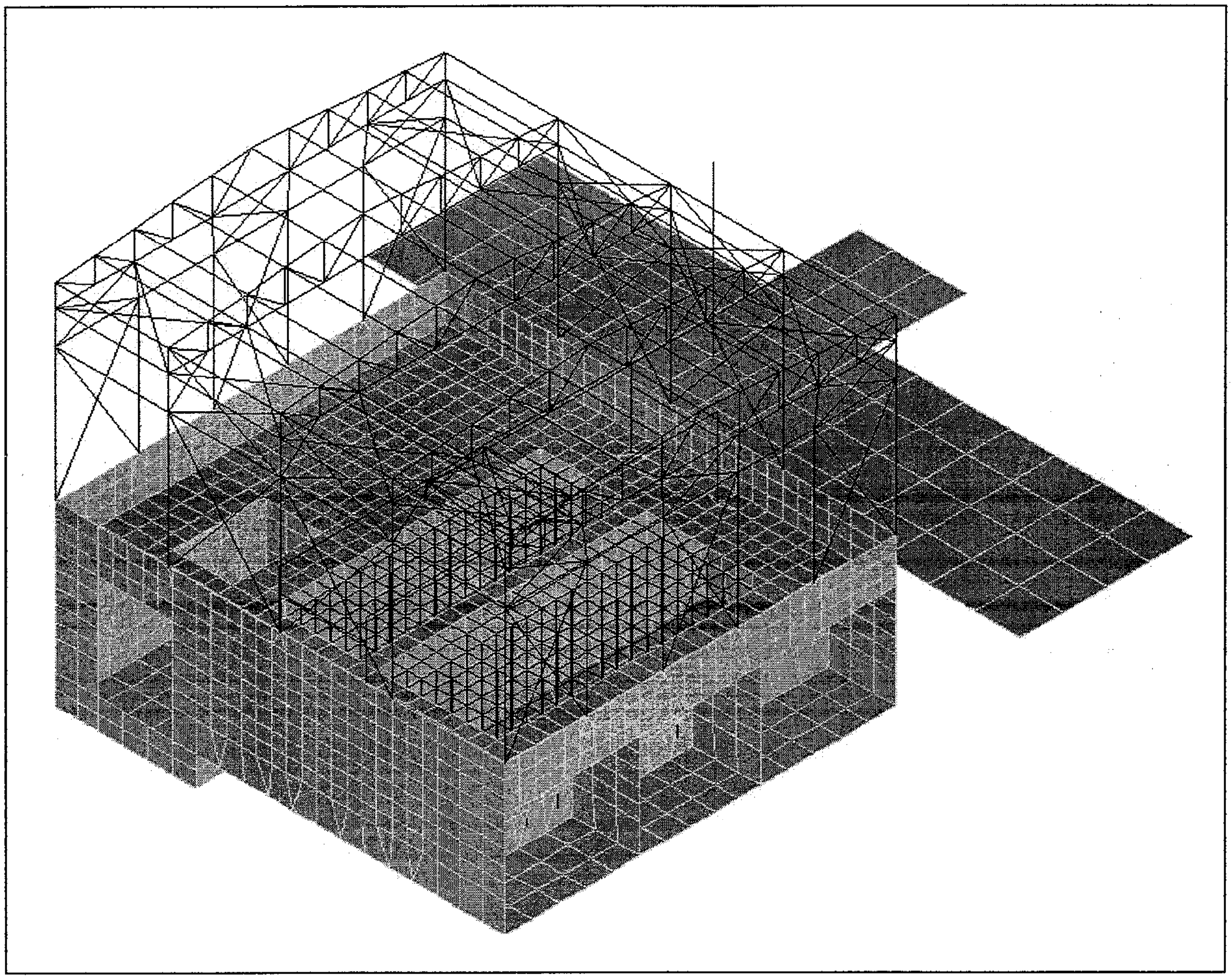


Figure 3.2-6
Transfer Area SSI Model

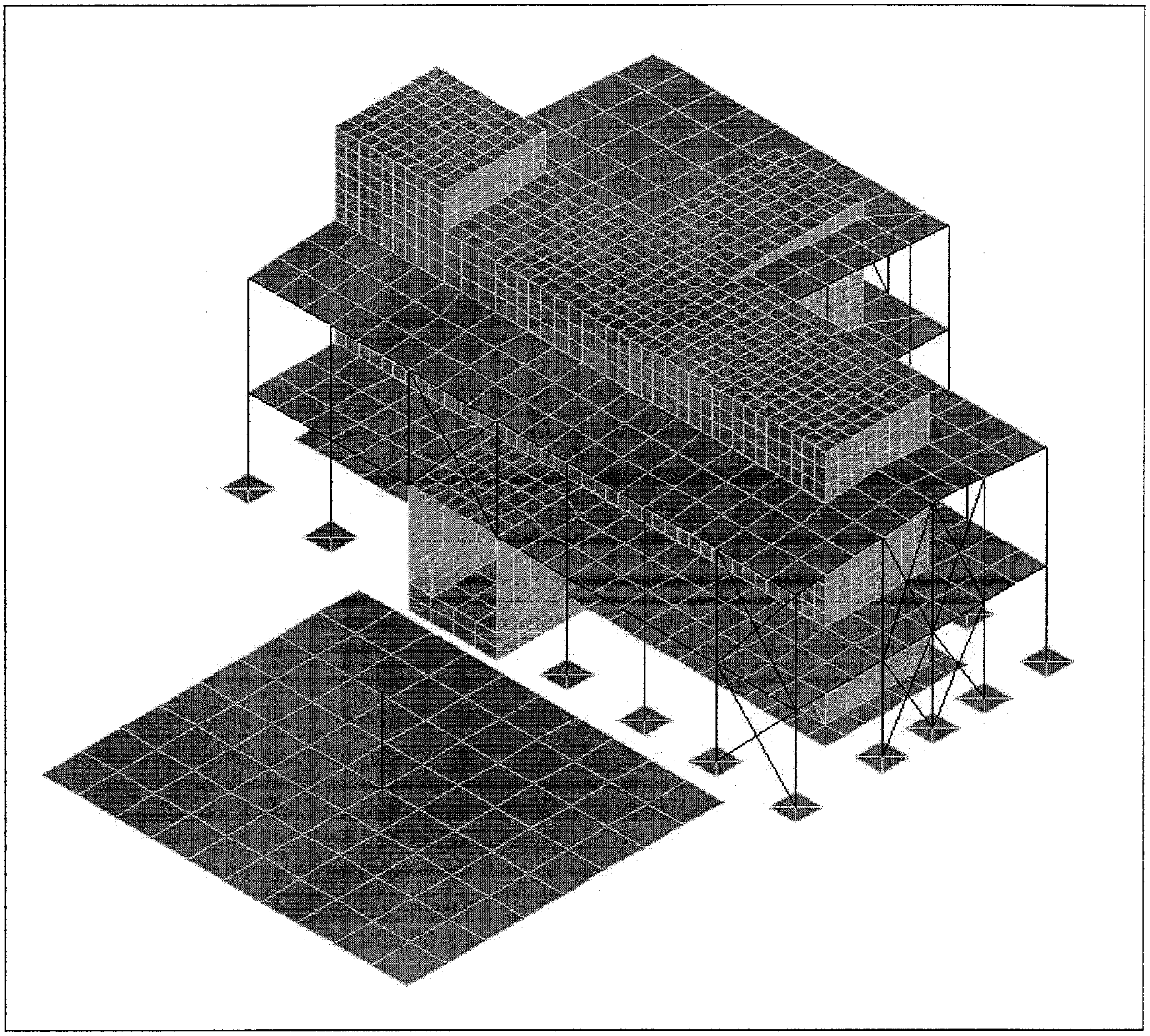


Figure 3.2-7
Cask Receipt Area Structural Finite Element Model

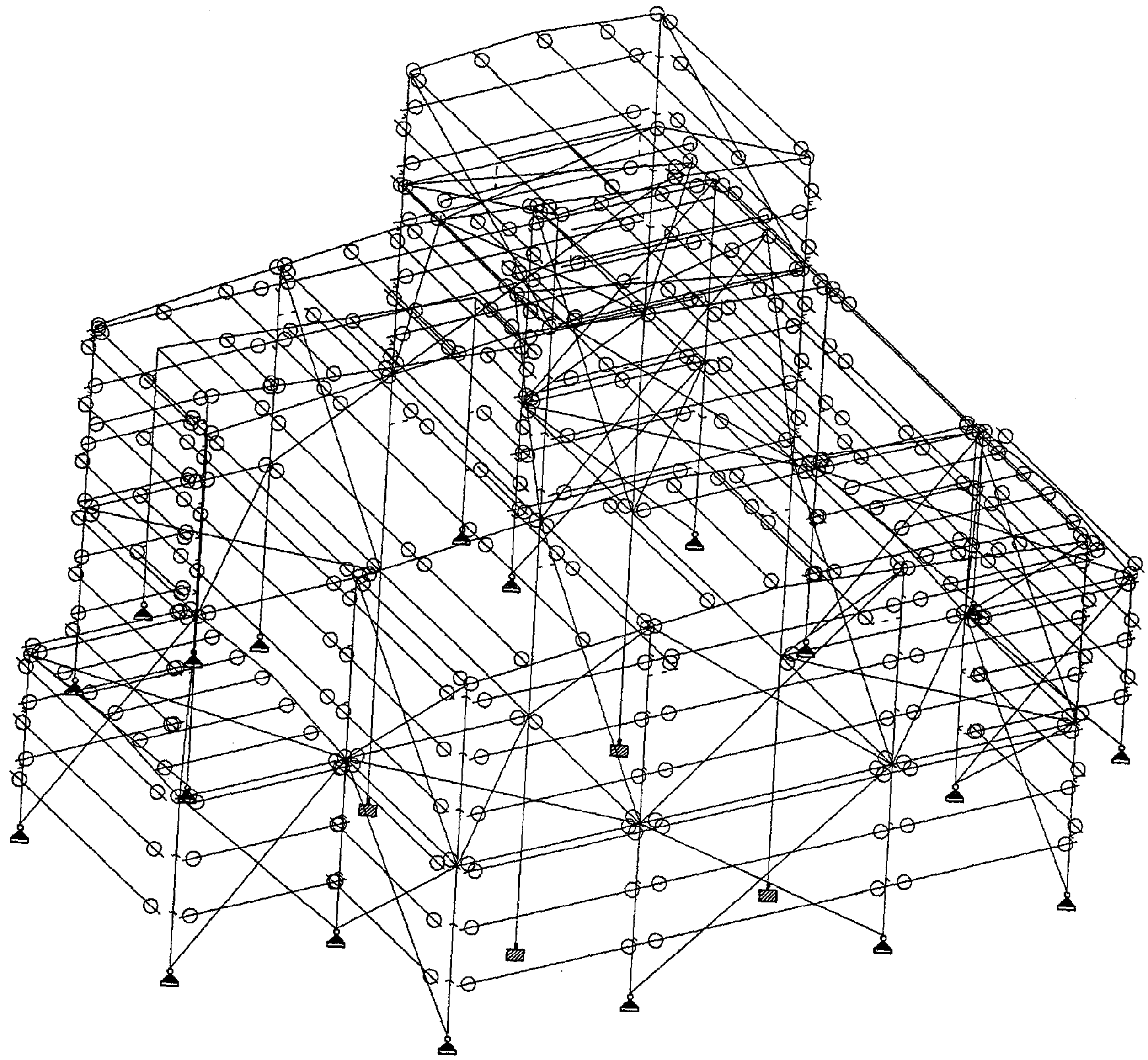


Figure 3.2-8
Transfer Area Structural Finite Element Model – South Elevation

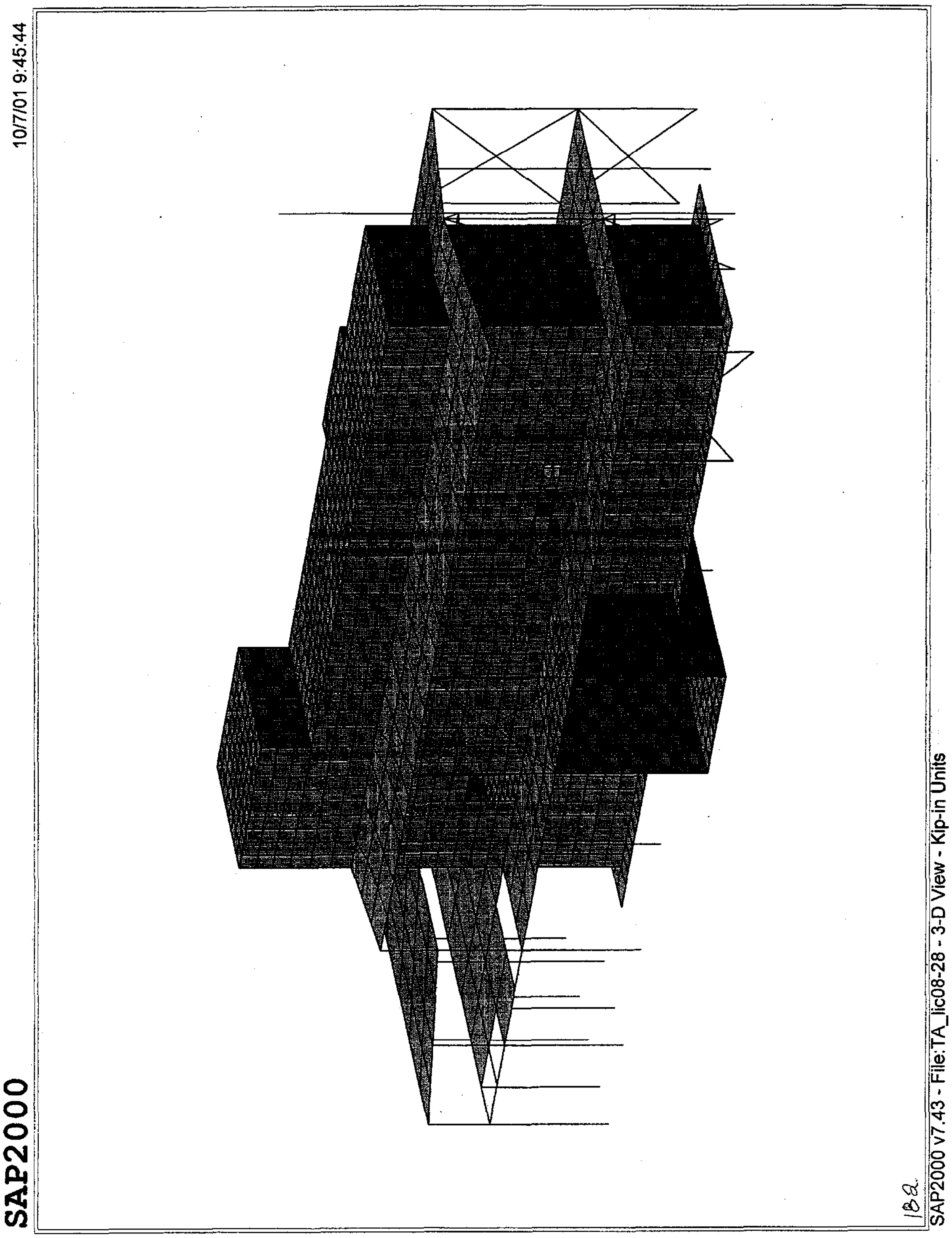


Figure 3.2-9
Transfer Area Structural Finite Element Model –North Elevation

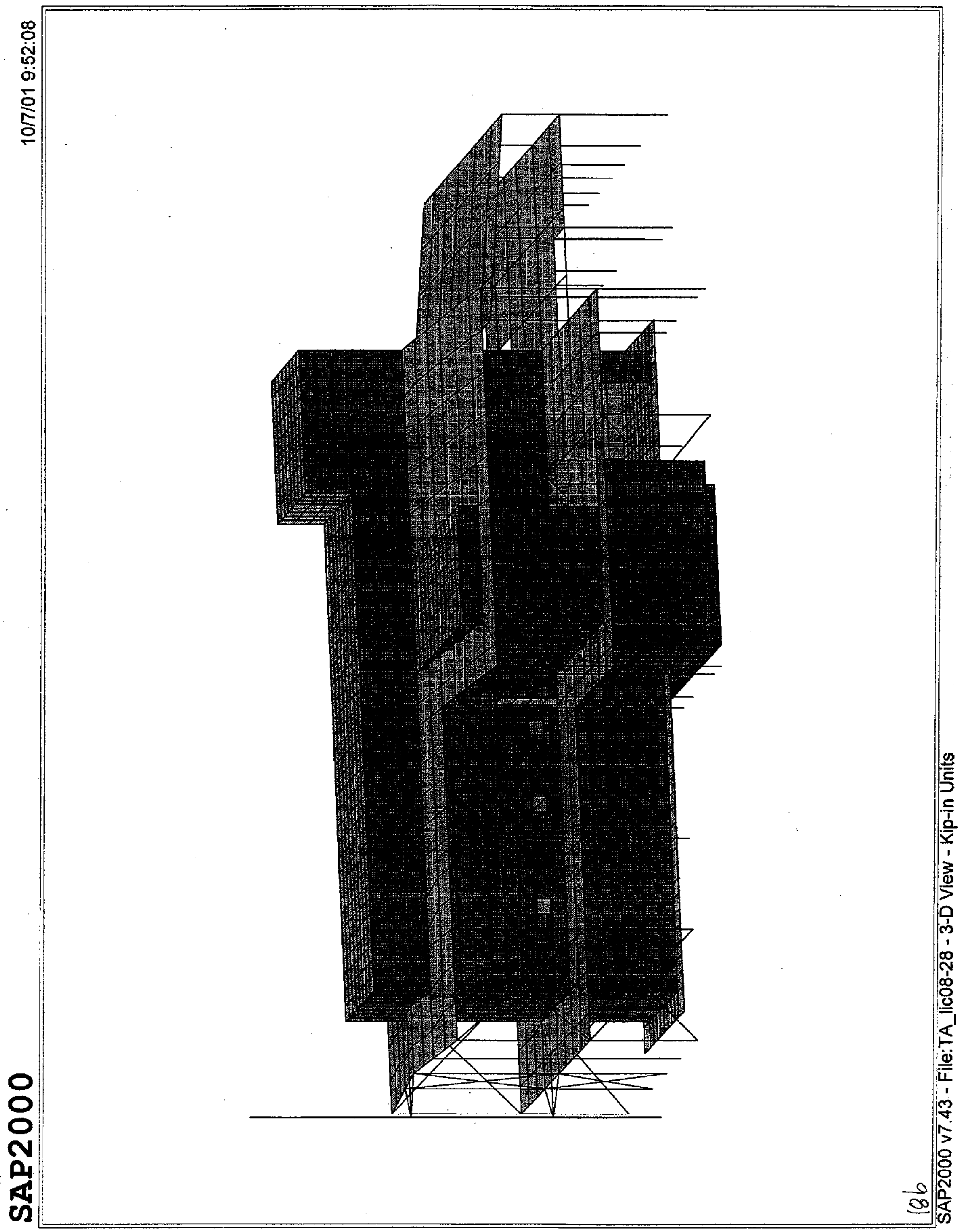


Figure 3.2-10
Storage Area Structural Finite Element Model

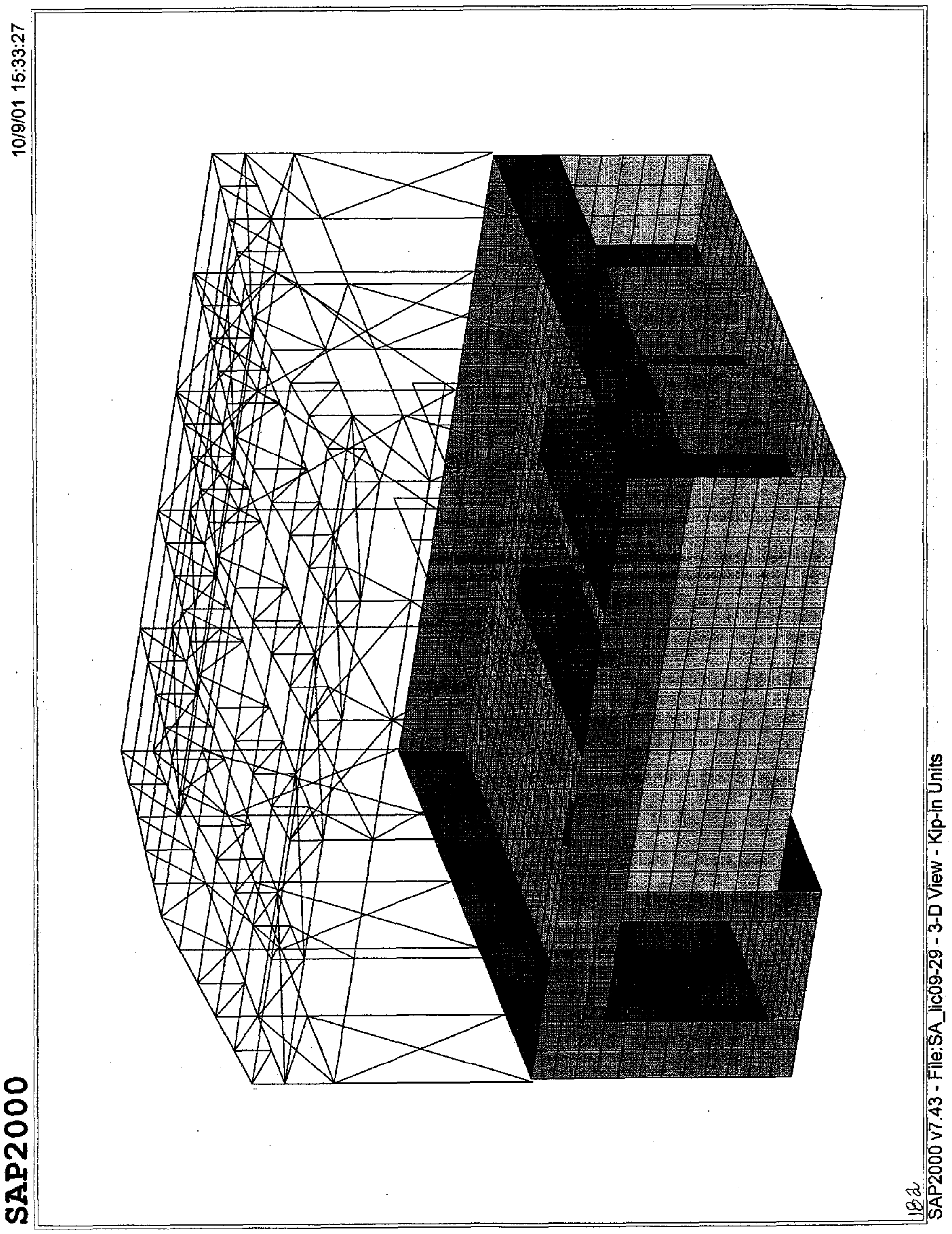
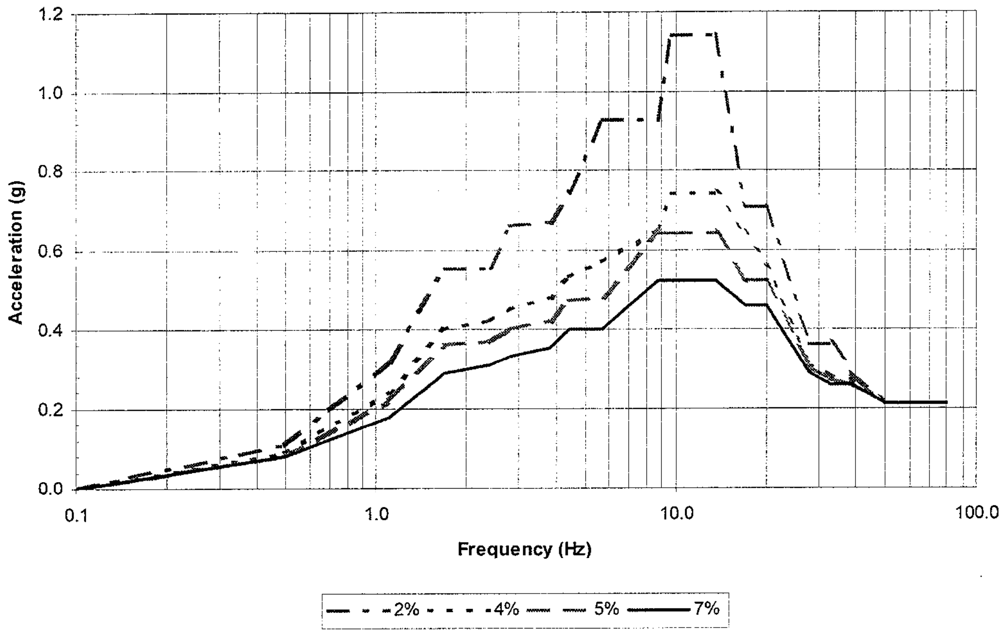


Figure 3.2-11
Cask Receipt Area
Base Motion Design Response Spectra
North-South Direction

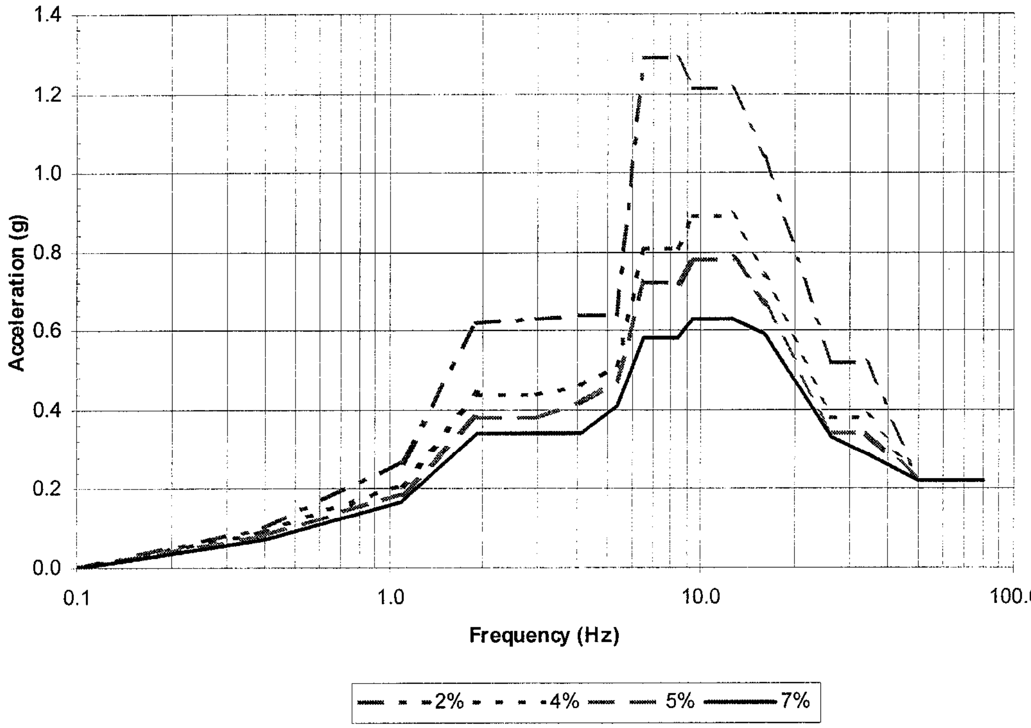


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.50	0.11	0.09	0.08	0.08
1.10	0.32	0.24	0.22	0.18
1.70	0.55	0.40	0.36	0.29
2.40	0.55	0.42	0.37	0.31
2.80	0.66	0.45	0.40	0.33
3.80	0.67	0.48	0.42	0.35
4.40	0.74	0.53	0.47	0.40
5.70	0.93	0.57	0.48	0.40
8.70	0.93	0.65	0.64	0.52
9.70	1.14	0.74	0.64	0.52
13.60	1.14	0.74	0.64	0.52
17.00	0.71	0.64	0.52	0.46
20.00	0.71	0.56	0.52	0.46
28.00	0.36	0.31	0.30	0.29
33.00	0.36	0.28	0.27	0.26
39.00	0.29	0.27	0.26	0.26
50.00	0.21	0.21	0.21	0.21
80.00	0.21	0.21	0.21	0.21

Affected major equipment: Main support columns

Figure 3.2-12
Cask Receipt Area
Base Motion Design Response Spectra
East-West Direction

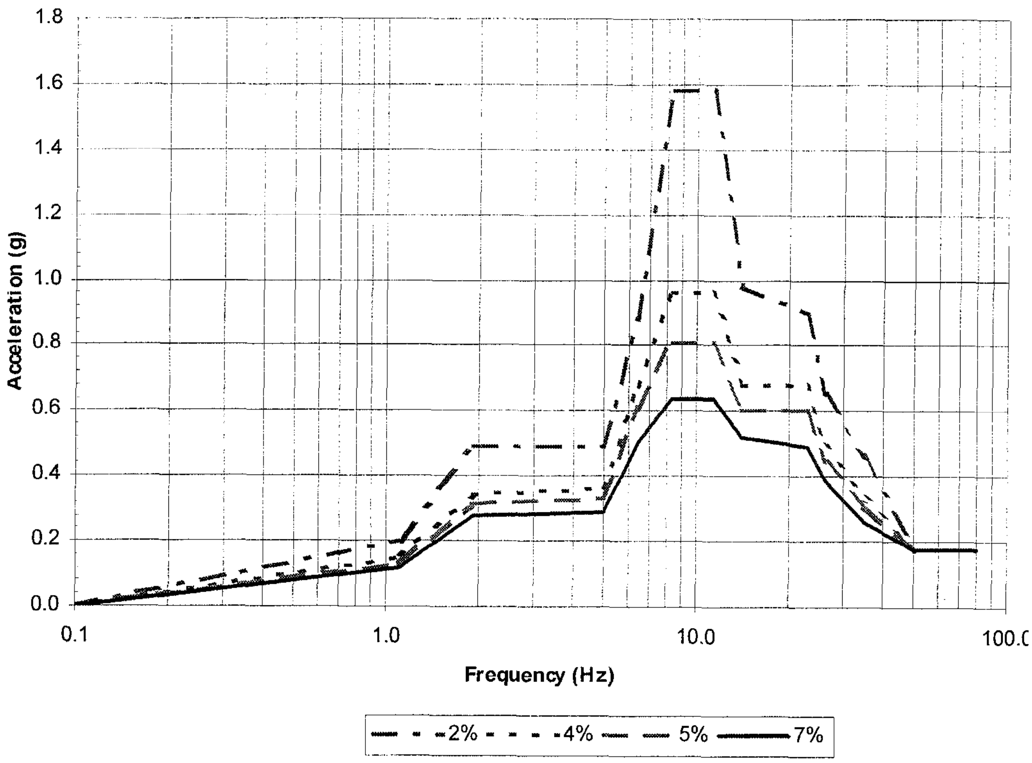


East-West Direction

Frequenc	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.10	0.27	0.21	0.19	0.17
1.90	0.62	0.44	0.38	0.34
3.00	0.63	0.44	0.38	0.34
4.10	0.64	0.46	0.42	0.34
5.40	0.64	0.51	0.47	0.41
6.50	1.29	0.81	0.72	0.58
8.40	1.29	0.81	0.72	0.58
9.40	1.21	0.89	0.78	0.63
12.70	1.21	0.89	0.78	0.63
16.00	1.04	0.74	0.67	0.59
26.00	0.52	0.38	0.34	0.33
34.00	0.52	0.38	0.34	0.29
50.00	0.22	0.22	0.22	0.22
80.00	0.22	0.22	0.22	0.22

Affected major equipment: Main support columns

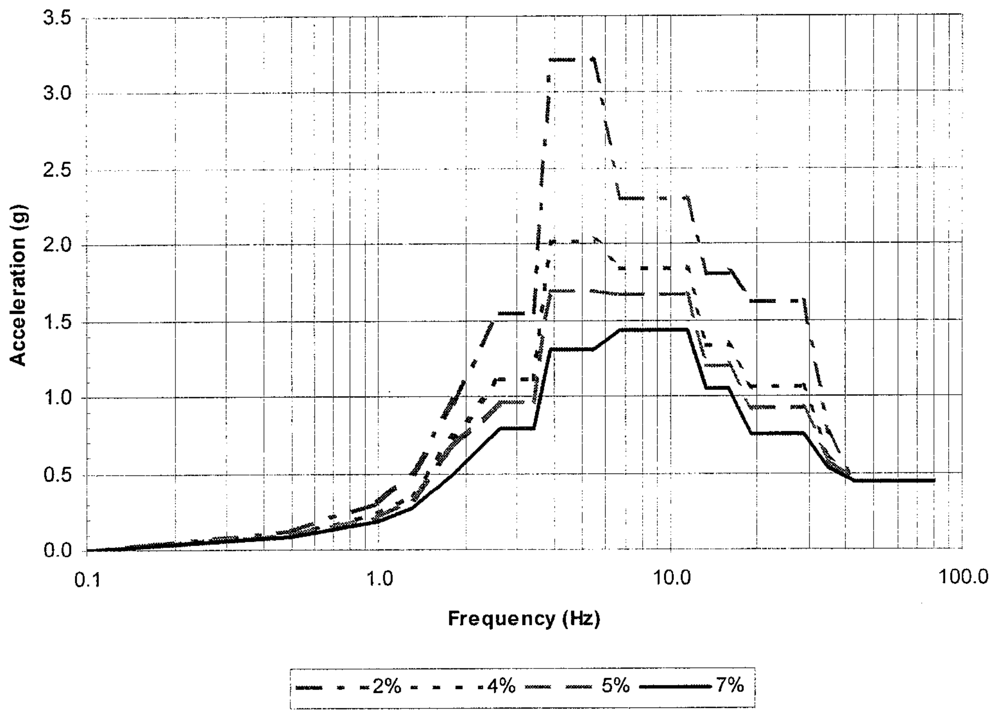
Figure 3.2-13
Cask Receipt Area
Base Motion Design Response Spectra
Vertical Direction



Vertical Direction				
Frequenc	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.10	0.20	0.15	0.13	0.12
1.90	0.49	0.34	0.31	0.28
5.00	0.49	0.36	0.33	0.29
6.50	0.88	0.67	0.61	0.50
8.30	1.58	0.96	0.81	0.64
11.40	1.58	0.96	0.81	0.64
14.00	0.98	0.68	0.60	0.52
23.00	0.90	0.68	0.60	0.49
26.00	0.65	0.49	0.44	0.39
35.00	0.46	0.33	0.31	0.26
50.00	0.18	0.18	0.18	0.18
80.00	0.18	0.18	0.18	0.18

Affected major equipment: Main support columns

Figure 3.2-14
Cask Receipt Area
Bridge Crane Level Design Response Spectra
North-South Direction

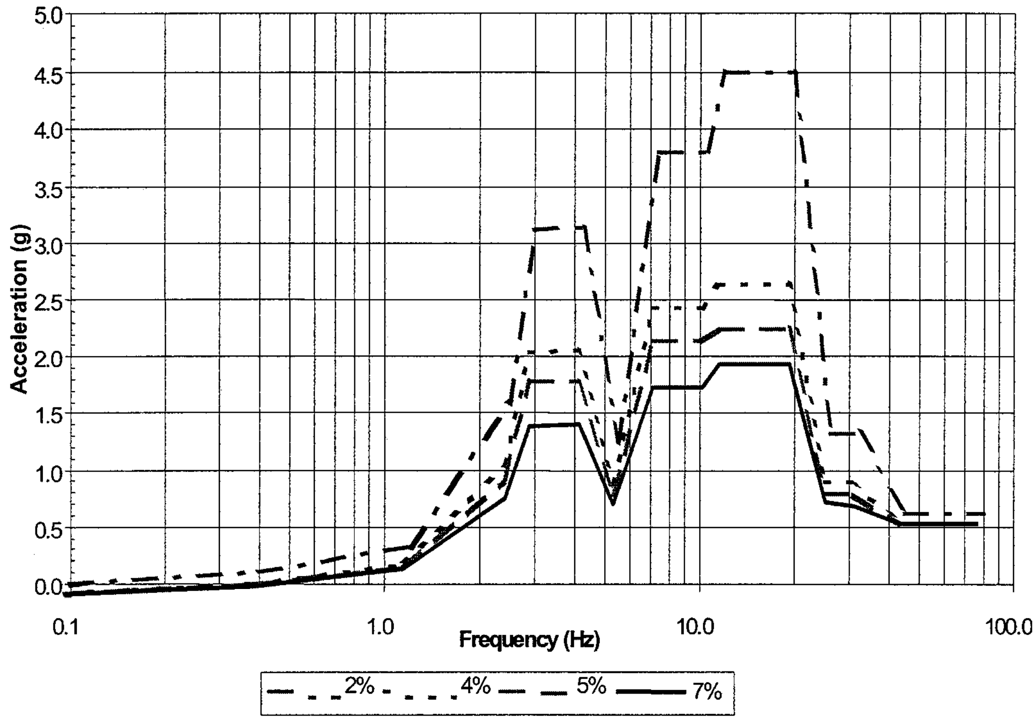


North-South Direction

Frequenc	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.50	0.12	0.10	0.10	0.09
1.00	0.31	0.24	0.21	0.19
1.30	0.51	0.36	0.33	0.27
1.80	0.96	0.73	0.68	0.50
2.60	1.55	1.11	0.97	0.79
3.40	1.55	1.11	0.97	0.79
3.90	3.21	2.01	1.69	1.31
5.50	3.21	2.01	1.69	1.31
6.70	2.30	1.84	1.67	1.43
11.50	2.30	1.84	1.67	1.43
13.40	1.80	1.33	1.20	1.05
16.00	1.80	1.33	1.20	1.05
19.00	1.62	1.06	0.93	0.75
29.00	1.62	1.06	0.93	0.75
35.00	0.76	0.61	0.58	0.53
43.00	0.44	0.44	0.44	0.44
80.00	0.44	0.44	0.44	0.44

Affected major equipment: Auxiliary bridge crane

Figure 3.2-15
Cask Receipt Area
Bridge Crane Level Design Response Spectra
East-West Direction

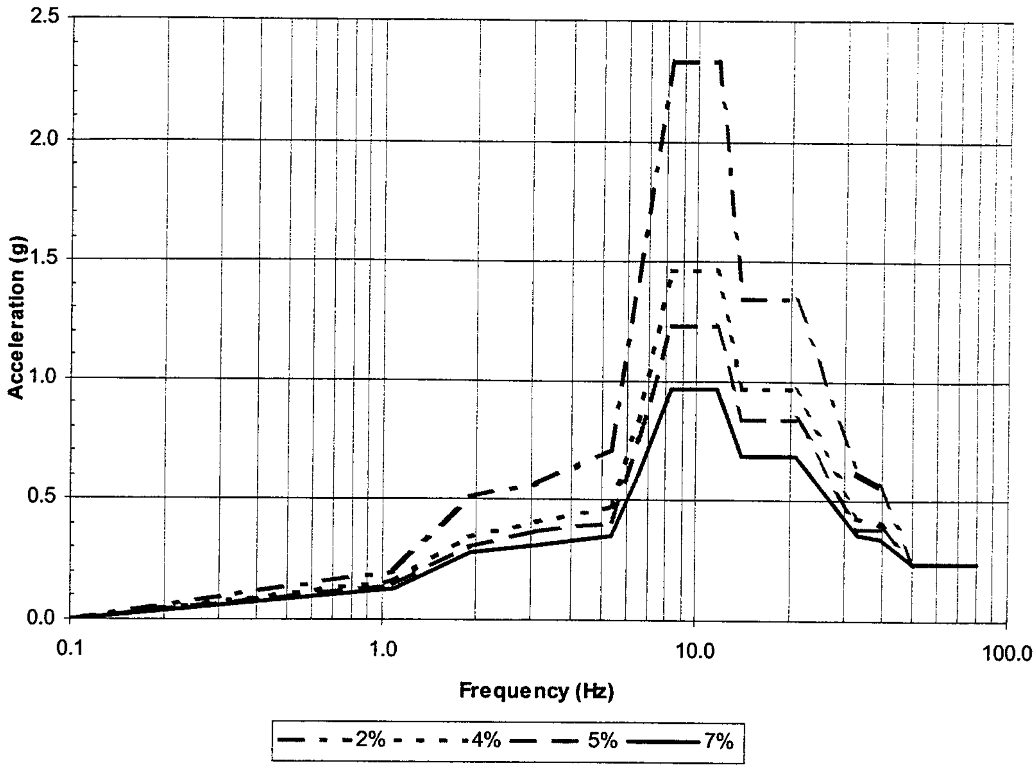


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.20	0.33	0.26	0.23	0.22
2.50	1.58	1.13	1.00	0.84
3.00	3.12	2.13	1.86	1.48
4.30	3.13	2.14	1.87	1.49
5.50	1.23	0.96	0.86	0.78
7.40	3.80	2.52	2.22	1.82
10.60	3.80	2.52	2.22	1.82
12.00	4.51	2.73	2.33	2.02
20.00	4.51	2.73	2.33	2.02
26.00	1.32	0.97	0.88	0.81
32.00	1.32	0.97	0.88	0.77
45.00	0.61	0.61	0.61	0.61
80.00	0.61	0.61	0.61	0.61

Affected major equipment: Auxiliary bridge crane

Figure 3.2-16
Cask Receipt Area
Bridge Crane Level Design Response Spectra
Vertical Direction

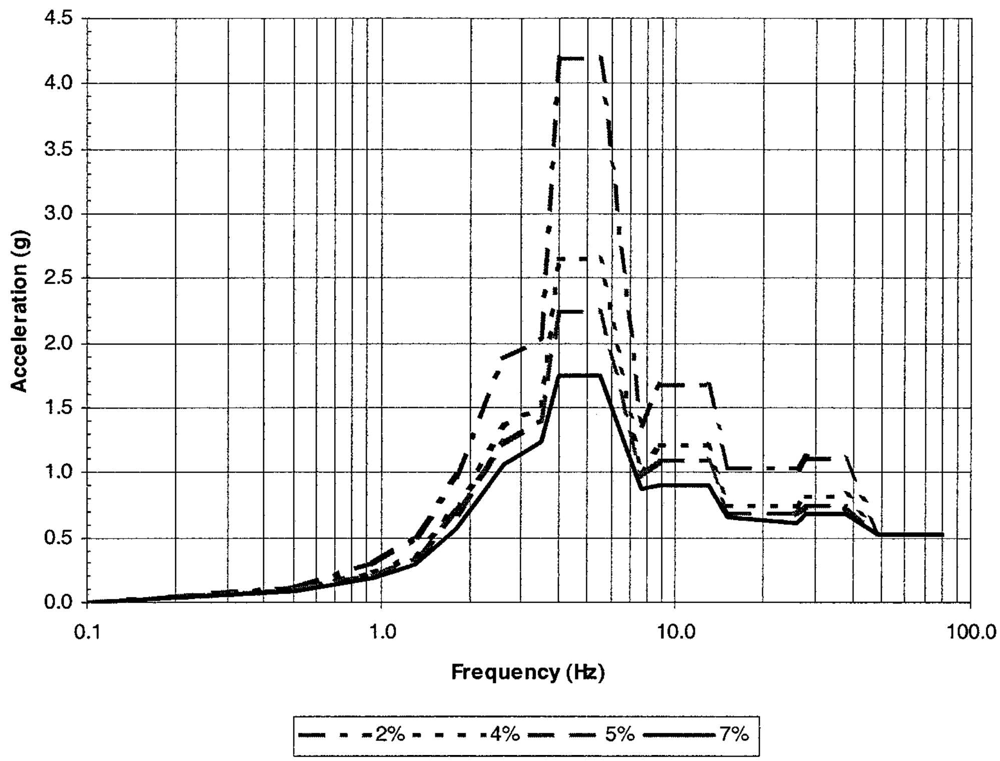


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.10	0.20	0.16	0.14	0.13
1.90	0.51	0.34	0.30	0.28
3.10	0.57	0.41	0.37	0.31
5.40	0.71	0.47	0.41	0.35
6.50	1.43	0.83	0.75	0.61
8.30	2.33	1.46	1.23	0.97
11.60	2.33	1.46	1.23	0.97
14.00	1.34	0.97	0.84	0.69
21.00	1.34	0.97	0.84	0.69
33.00	0.62	0.43	0.38	0.36
39.00	0.57	0.40	0.38	0.34
50.00	0.24	0.24	0.24	0.24
80.00	0.24	0.24	0.24	0.24

Affected major equipment: Auxiliary bridge crane

Figure 3.2-17
Cask Receipt Area
Cask Receipt Crane Level Design Response Spectra
North-South Direction

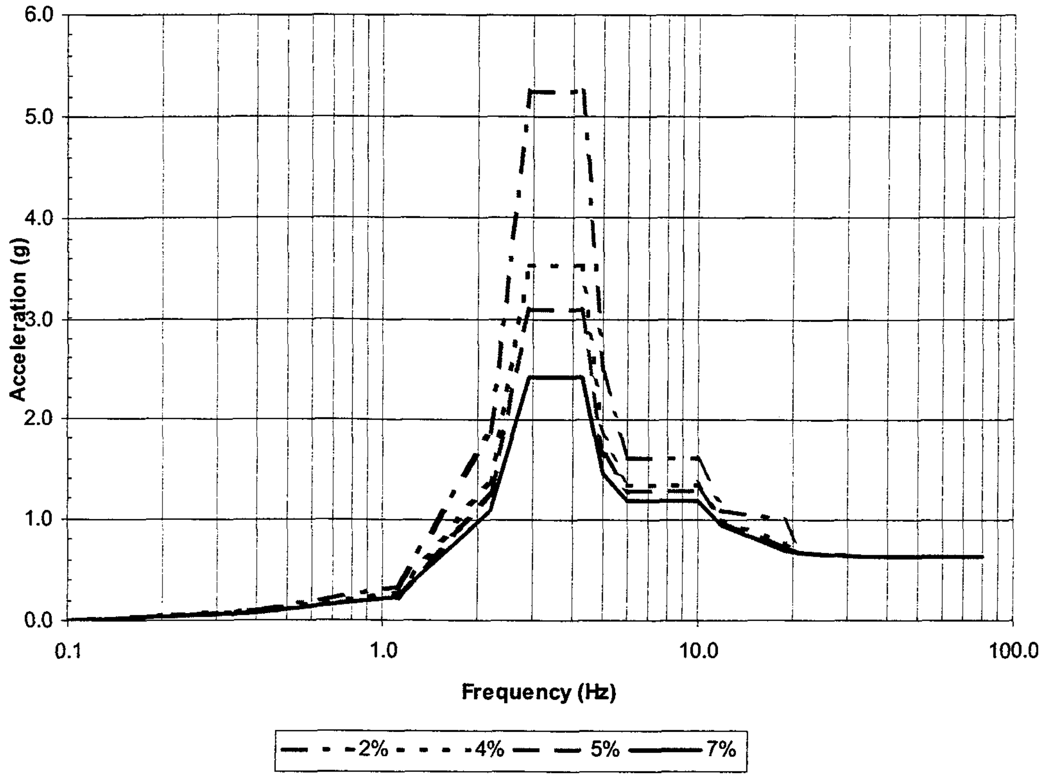


North-South Direction

Frequenc	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.51	0.12	0.10	0.10	0.09
0.95	0.31	0.24	0.21	0.19
1.30	0.51	0.36	0.33	0.29
1.80	0.96	0.73	0.68	0.57
2.60	1.88	1.36	1.23	1.06
3.50	2.04	1.52	1.40	1.24
4.00	4.20	2.65	2.24	1.75
5.50	4.20	2.65	2.24	1.75
7.60	1.35	1.01	0.97	0.87
8.90	1.67	1.21	1.09	0.91
13.00	1.67	1.21	1.09	0.91
15.00	1.03	0.74	0.69	0.65
26.00	1.03	0.74	0.69	0.61
28.00	1.10	0.82	0.75	0.68
38.00	1.10	0.82	0.75	0.68
49.00	0.53	0.53	0.53	0.53
80.00	0.53	0.53	0.53	0.53

Affected major equipment: Cask receipt crane

Figure 3.2-18
Cask Receipt Area
Cask Receipt Crane Level Design Response Spectra
East-West Direction

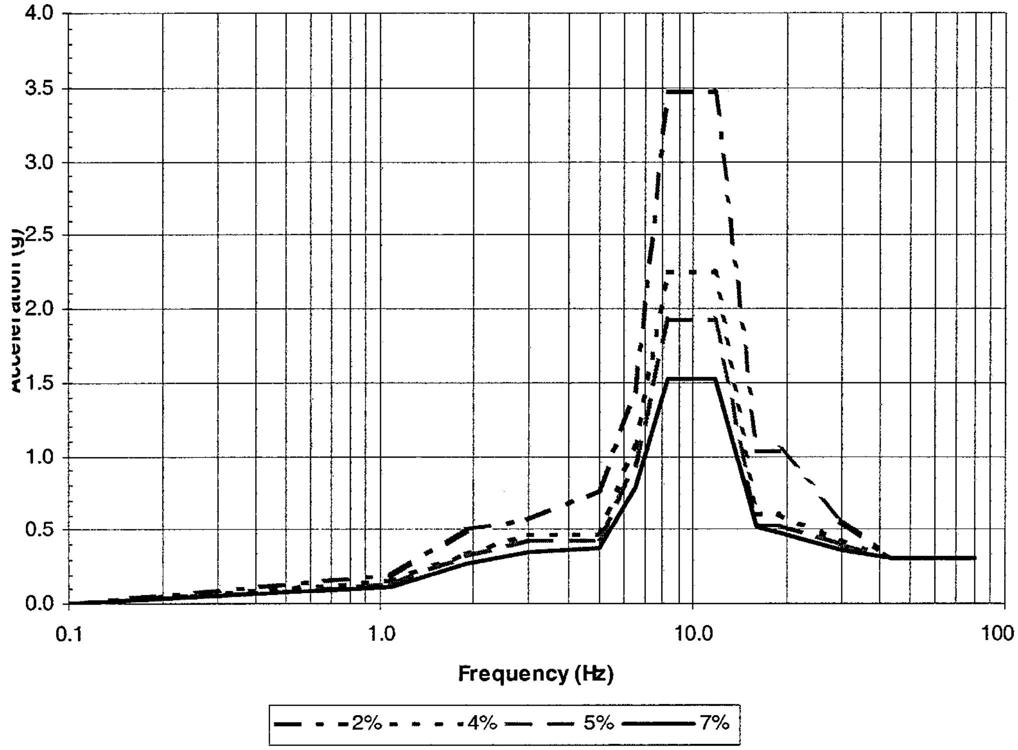


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.10	0.33	0.26	0.23	0.23
2.20	1.85	1.37	1.23	1.09
2.90	5.25	3.53	3.08	2.42
4.30	5.25	3.53	3.08	2.42
5.00	2.47	1.82	1.62	1.46
6.00	1.61	1.35	1.28	1.19
10.00	1.61	1.35	1.28	1.19
12.00	1.09	1.00	0.97	0.93
19.00	0.99	0.76	0.73	0.69
21.00	0.67	0.67	0.67	0.67
33.00	0.63	0.63	0.63	0.63
80.00	0.63	0.63	0.63	0.63

Affected major equipment: Cask receipt crane

Figure 3.2-19
Cask Receipt Area
Cask Receipt Crane Level Design Response Spectra
Vertical Direction

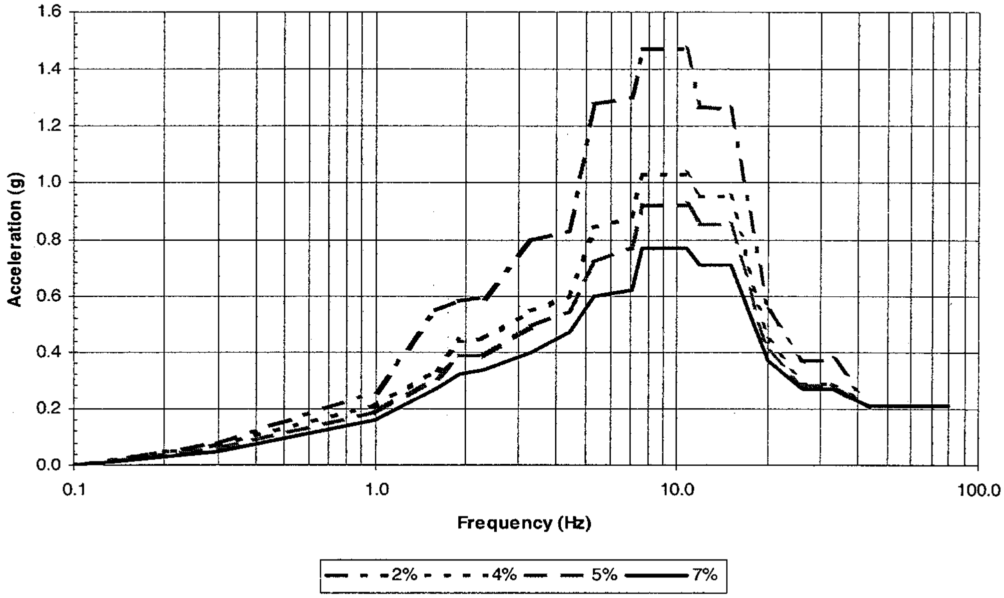


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.10	0.20	0.15	0.13	0.12
1.90	0.50	0.34	0.32	0.27
3.00	0.57	0.46	0.42	0.35
5.00	0.76	0.47	0.42	0.37
6.50	1.43	1.06	0.93	0.79
8.30	3.47	2.25	1.92	1.52
11.80	3.47	2.25	1.92	1.52
16.00	1.03	0.61	0.53	0.52
19.00	1.03	0.61	0.53	0.48
30.00	0.57	0.43	0.40	0.36
43.00	0.31	0.31	0.31	0.31
80.00	0.31	0.31	0.31	0.31

Affected major equipment: Cask receipt crane

Figure 3.2-20
Storage Area
Base Mat Design Response Spectra
North-South Direction

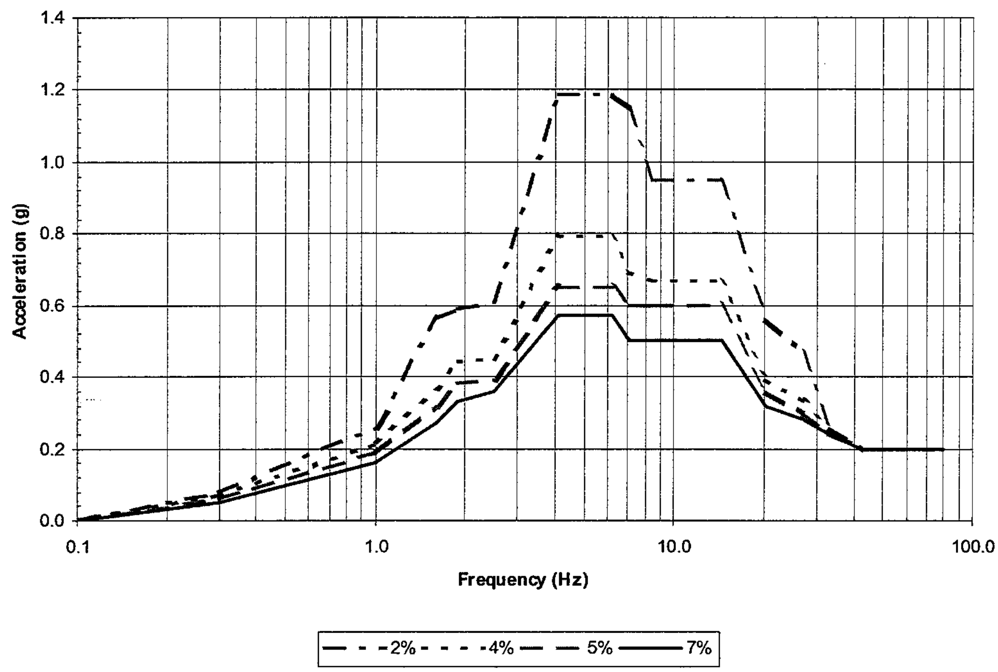


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.55	0.34	0.31	0.27
1.90	0.58	0.44	0.39	0.32
2.30	0.59	0.45	0.39	0.34
3.30	0.80	0.55	0.49	0.40
4.40	0.83	0.60	0.54	0.47
5.30	1.28	0.84	0.72	0.60
7.10	1.30	0.88	0.77	0.62
7.70	1.47	1.03	0.92	0.77
10.70	1.47	1.03	0.92	0.77
11.90	1.27	0.95	0.85	0.71
15.00	1.26	0.95	0.85	0.71
20.00	0.54	0.44	0.40	0.37
26.00	0.37	0.29	0.28	0.27
33.00	0.37	0.29	0.28	0.27
43.00	0.21	0.21	0.21	0.21
80.00	0.21	0.21	0.21	0.21

Affected major equipment: Building structure

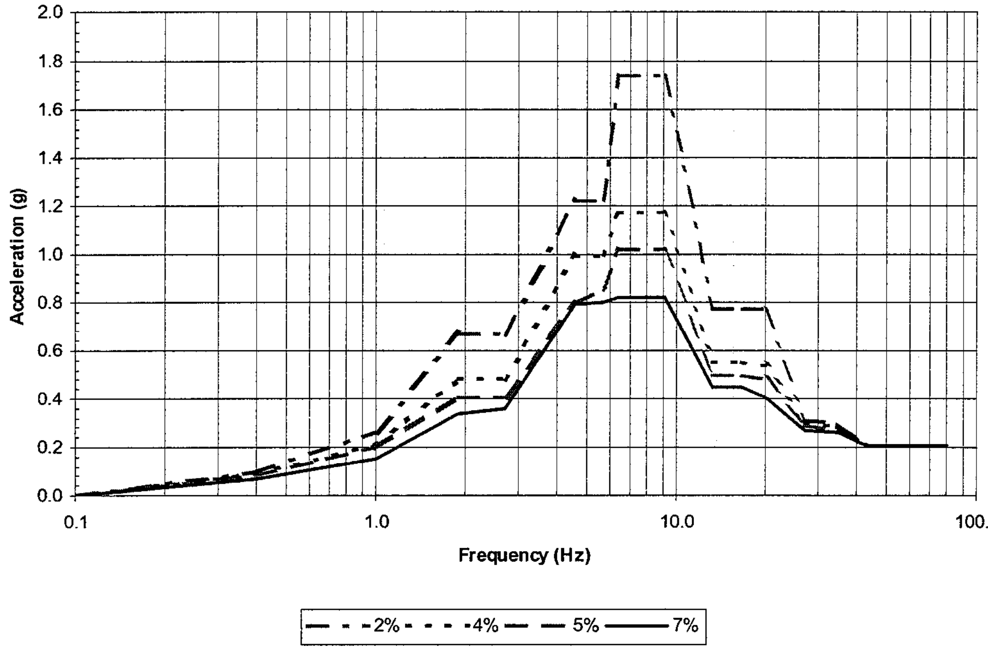
Figure 3.2-21
Storage Area
Base Motion Design Response Spectra
North-South Direction



	North-South Direction			
Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.56	0.37	0.32	0.27
1.90	0.59	0.44	0.38	0.33
2.50	0.61	0.45	0.39	0.36
4.10	1.19	0.79	0.65	0.57
6.20	1.19	0.79	0.65	0.57
7.10	1.15	0.69	0.60	0.50
8.40	0.95	0.67	0.60	0.50
14.40	0.95	0.67	0.60	0.50
20.30	0.56	0.39	0.36	0.32
27.00	0.47	0.33	0.30	0.28
33.00	0.26	0.25	0.24	0.24
43.00	0.20	0.20	0.20	0.20
80.00	0.20	0.20	0.20	0.20

Affected major equipment: Building structure, HVAC equipment, Electrical Room equipment

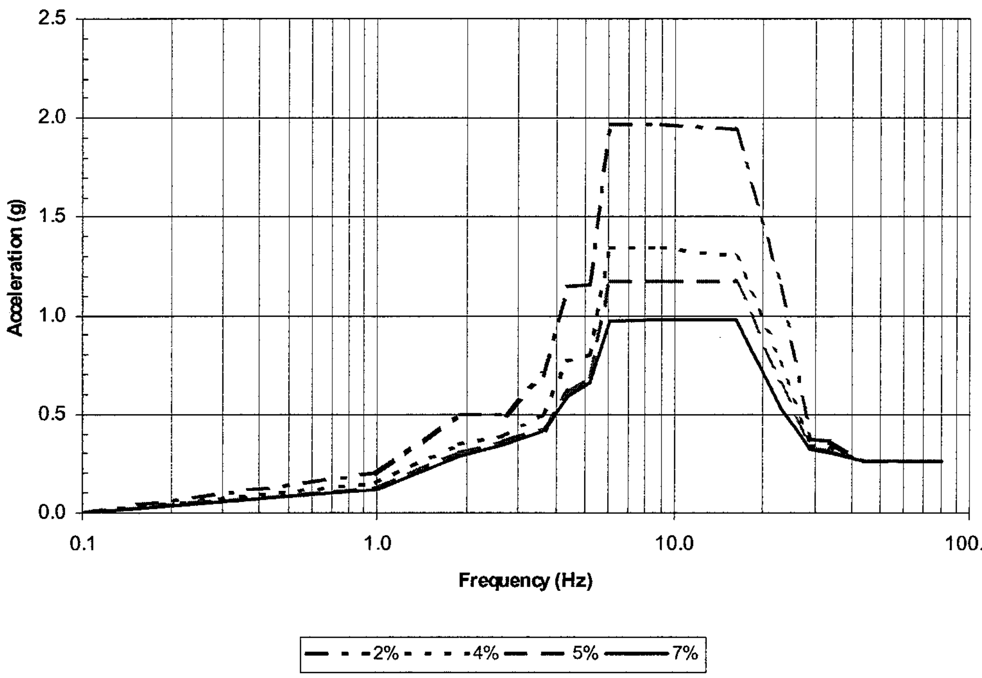
Figure 3.2-22
Transfer Area
Base Motion Design Response Spectra
East-West Direction



East-West Direction				
Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.26	0.21	0.20	0.15
1.90	0.67	0.48	0.41	0.34
2.70	0.67	0.48	0.41	0.36
4.60	1.22	0.99	0.79	0.79
5.70	1.22	0.99	0.85	0.80
6.40	1.74	1.17	1.02	0.82
9.20	1.74	1.17	1.02	0.82
13.20	0.77	0.55	0.50	0.45
16.60	0.77	0.55	0.50	0.45
20.00	0.77	0.54	0.48	0.41
27.00	0.31	0.30	0.29	0.27
35.00	0.30	0.28	0.27	0.26
43.00	0.21	0.21	0.21	0.21
80.00	0.21	0.21	0.21	0.21

Affected major equipment: Building structure, HVAC equipment, Electrical Room equipment

Figure 3.2-23
Transfer Area
Base Motion Design Response Spectra
Vertical Direction

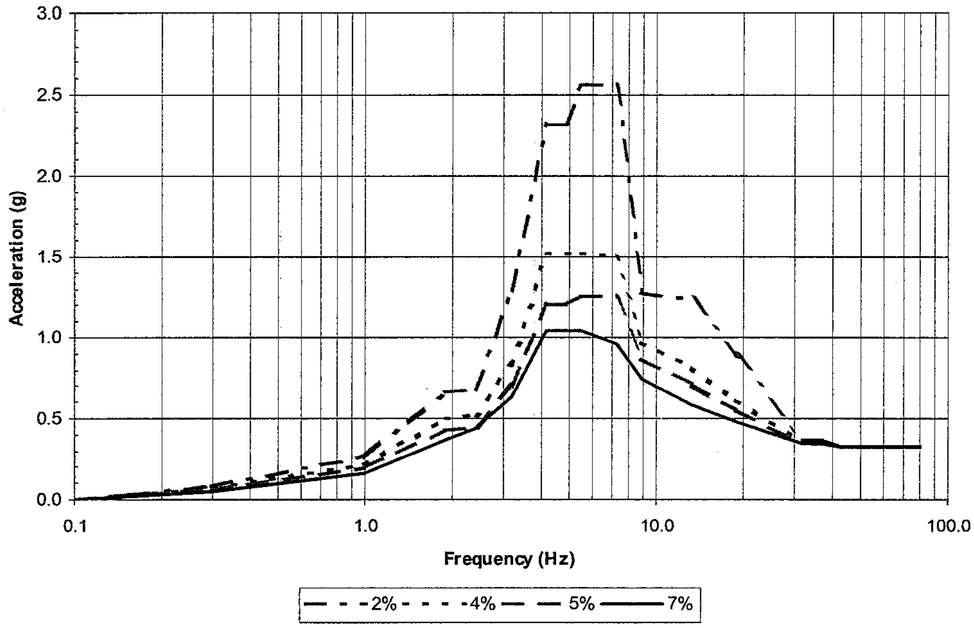


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.90	0.50	0.35	0.30	0.29
2.70	0.50	0.39	0.36	0.35
3.60	0.69	0.50	0.42	0.41
4.40	1.15	0.77	0.61	0.59
5.20	1.16	0.80	0.68	0.66
6.10	1.97	1.34	1.17	0.97
9.10	1.97	1.34	1.17	0.98
16.20	1.94	1.30	1.17	0.98
23.00	1.15	0.76	0.66	0.53
29.00	0.37	0.34	0.33	0.32
34.00	0.36	0.33	0.31	0.30
44.00	0.26	0.26	0.26	0.26
80.00	0.26	0.26	0.26	0.26

Affected major equipment: Building structure, HVAC equipment, Electrical Room equipment

Figure 3.2-24
Transfer Area
2nd Floor Level CMS-FPA Design Response Spectra
North-South Direction

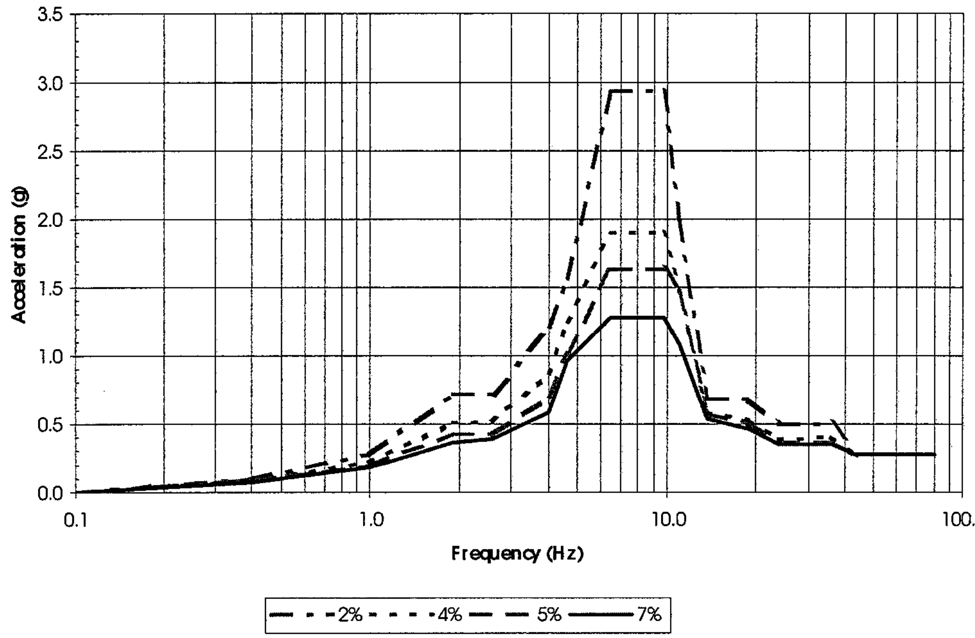


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.27	0.21	0.19	0.16
1.90	0.66	0.50	0.43	0.37
2.40	0.67	0.52	0.45	0.44
3.20	1.29	0.83	0.69	0.63
4.20	2.32	1.52	1.20	1.04
4.90	2.32	1.52	1.20	1.04
5.50	2.56	1.52	1.26	1.04
7.30	2.56	1.50	1.26	0.96
8.90	1.28	0.97	0.87	0.74
13.30	1.23	0.82	0.71	0.58
19.00	0.89	0.61	0.55	0.48
32.00	0.37	0.36	0.35	0.35
37.00	0.37	0.36	0.35	0.35
43.00	0.33	0.33	0.33	0.33
80.00	0.33	0.33	0.33	0.33

Affected major equipment: Shield windows, bench vessel structures, personnel shield door, master slave manipulators, waste transfer port plugs, fuel transfer port plugs, in-cell equipment.

Figure 3.2-25
Transfer Area
2nd Floor Level CMS-FPA Design Response Spectra
East-West Direction

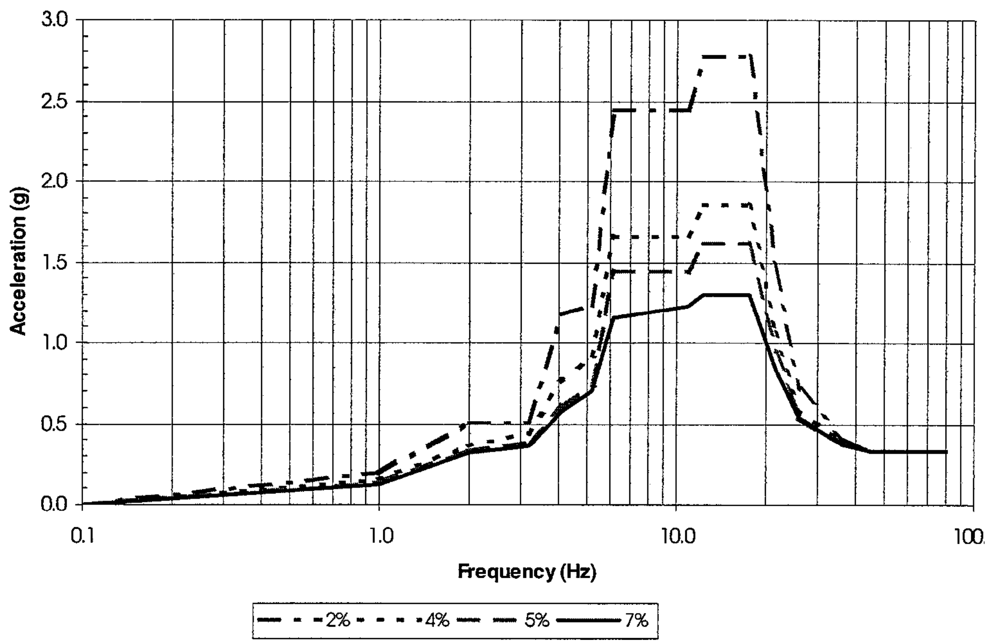


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.28	0.22	0.20	0.18
1.90	0.72	0.51	0.43	0.36
2.60	0.72	0.51	0.43	0.39
4.00	1.21	0.87	0.70	0.59
4.60	1.56	1.25	1.01	0.96
6.50	2.94	1.90	1.63	1.28
9.80	2.94	1.90	1.63	1.28
11.00	1.99	1.48	1.47	1.08
13.70	0.68	0.59	0.57	0.54
19.00	0.68	0.52	0.51	0.46
24.00	0.50	0.39	0.37	0.35
36.00	0.50	0.40	0.36	0.35
43.00	0.28	0.28	0.28	0.28
80.00	0.28	0.28	0.28	0.28

Affected major equipment: Shield windows, bench vessel structures, personnel shield door, master slave manipulators, waste transfer port plugs, fuel transfer port plugs, in-cell equipment

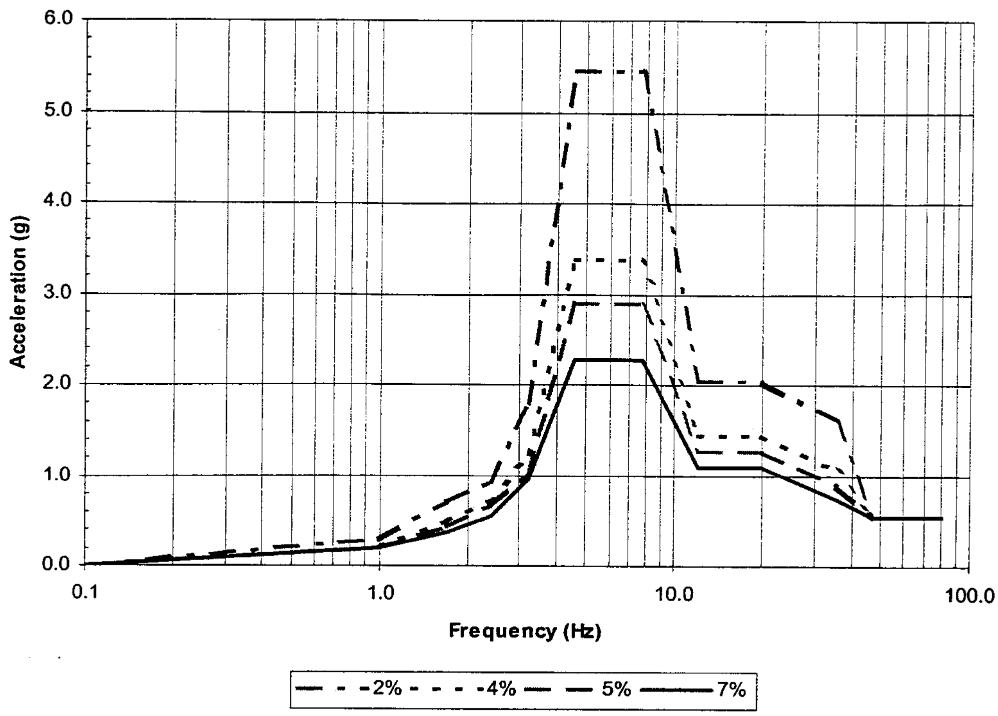
Figure 3.2-26
Transfer Area
2nd Floor Level CMS-FPA Design Response Spectra
Vertical Direction



Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
2.00	0.51	0.36	0.33	0.32
3.20	0.51	0.44	0.38	0.36
4.10	1.18	0.76	0.60	0.58
5.20	1.23	0.92	0.73	0.70
6.10	2.44	1.66	1.44	1.15
11.00	2.44	1.66	1.44	1.23
12.30	2.77	1.86	1.62	1.30
17.50	2.77	1.86	1.62	1.30
21.50	1.45	1.06	0.95	0.84
26.00	0.71	0.59	0.55	0.54
36.00	0.41	0.39	0.38	0.37
45.00	0.33	0.33	0.33	0.33
80.00	0.33	0.33	0.33	0.33

Affected major equipment: Shield windows, bench vessel structures, personnel shield door, master slave manipulators, waste transfer port plugs, fuel transport port plugs, in-cell equipment.

Figure 3.2-27
Transfer Area
FHM Level Design Response Spectra
North-South Direction

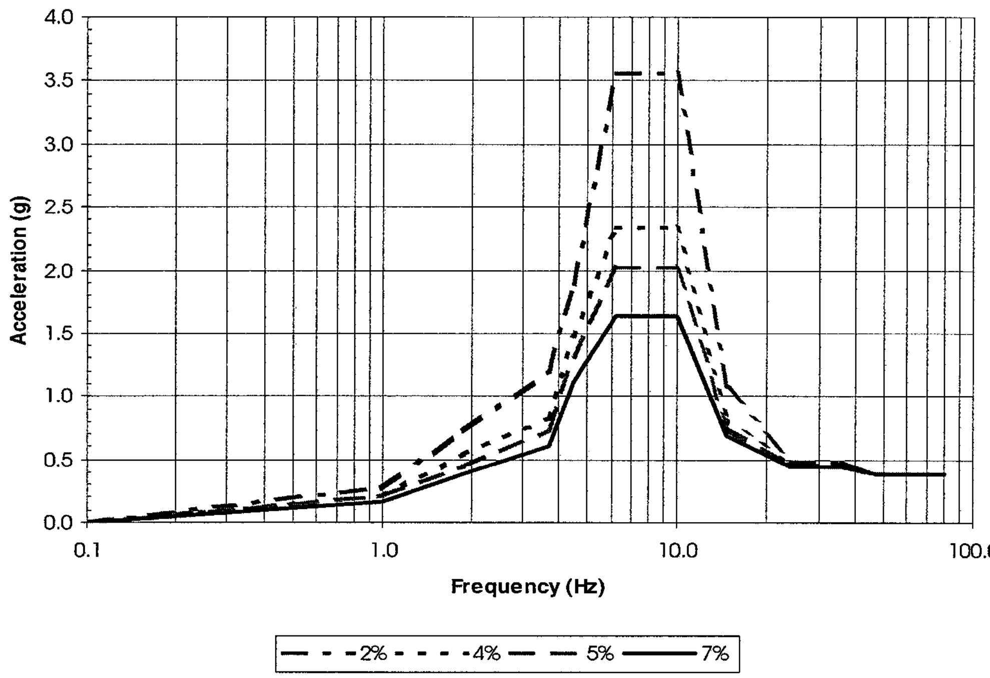


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.30	0.20	0.20	0.20
1.70	0.69	0.49	0.43	0.37
2.40	0.92	0.72	0.66	0.55
3.20	1.78	1.23	1.01	0.95
4.60	5.46	3.38	2.89	2.27
7.70	5.46	3.38	2.89	2.27
12.00	2.03	1.44	1.27	1.08
20.00	2.03	1.44	1.27	1.08
36.00	1.62	1.05	0.90	0.73
47.00	0.54	0.54	0.54	0.54
80.00	0.54	0.54	0.54	0.54

Affected major equipment: Fuel handling machine, in-cell lights

Figure 3.2-28
Transfer Area
FHM Level Design Response Spectra
East-West Direction

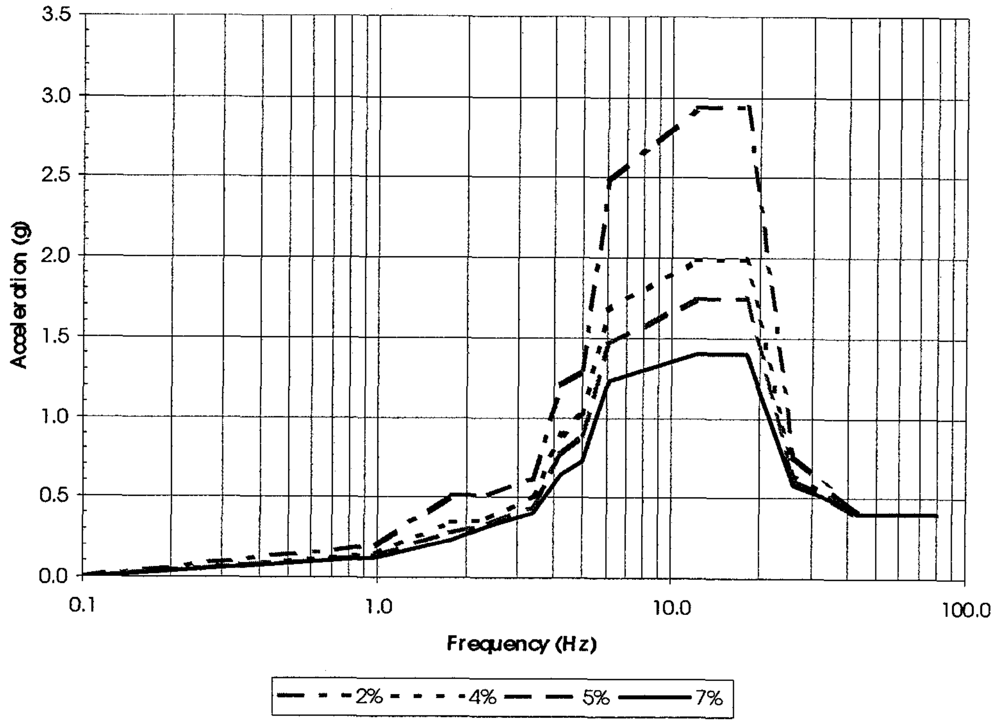


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.27	0.21	0.20	0.16
1.90	0.73	0.53	0.44	0.39
3.70	1.20	0.83	0.73	0.61
4.50	1.89	1.47	1.31	1.11
6.20	3.56	2.34	2.02	1.64
10.00	3.56	2.34	2.02	1.64
14.60	1.06	0.83	0.75	0.69
24.00	0.48	0.46	0.45	0.44
36.00	0.48	0.46	0.45	0.44
47.00	0.38	0.38	0.38	0.38
80.00	0.38	0.38	0.38	0.38

Affected major equipment: Fuel handling machine, in-cell lights

Figure 3.2-29
Transfer Area
FHM Level Design Response Spectra
Vertical Direction

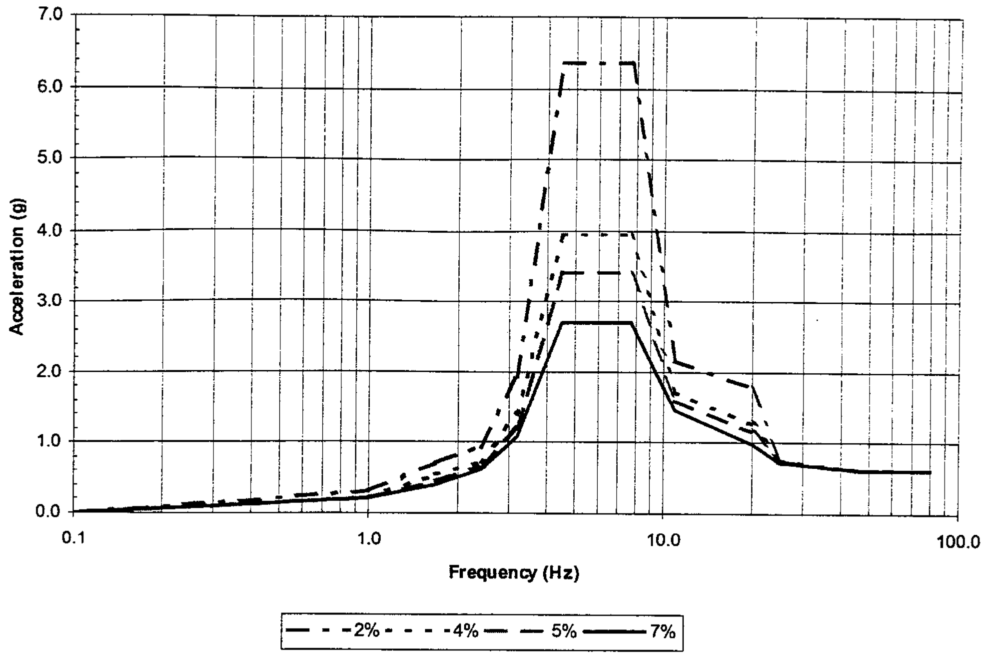


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.80	0.51	0.35	0.28	0.24
2.40	0.51	0.37	0.34	0.32
3.40	0.62	0.50	0.44	0.40
4.20	1.21	0.90	0.77	0.65
5.00	1.30	1.02	0.88	0.73
6.10	2.48	1.68	1.47	1.23
12.00	2.94	1.99	1.75	1.40
18.00	2.94	1.99	1.75	1.40
26.00	0.77	0.65	0.61	0.58
36.00	0.54	0.50	0.49	0.48
44.00	0.40	0.40	0.40	0.40
80.00	0.40	0.40	0.40	0.40

Affected major equipment: Fuel handling machine, in-cell lights

Figure 3.2-30
Transfer Area
68-Foot Level Design Response Spectra
North-South Direction

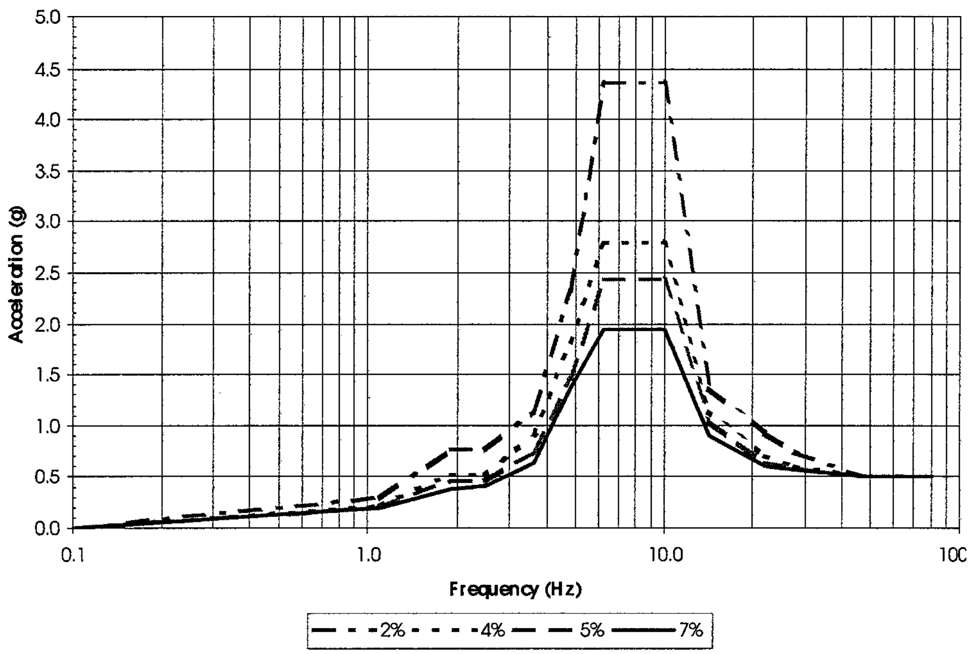


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.30	0.20	0.20	0.20
1.70	0.71	0.53	0.45	0.39
2.40	0.94	0.72	0.66	0.60
3.20	1.93	1.39	1.17	1.09
4.50	6.37	3.95	3.40	2.71
7.70	6.37	3.95	3.40	2.71
10.90	2.15	1.72	1.60	1.46
20.00	1.79	1.27	1.14	0.99
25.00	0.74	0.74	0.73	0.73
47.00	0.61	0.61	0.61	0.61
80.00	0.61	0.61	0.61	0.61

Affected major equipment: Shield door

Figure 3.2-31
Transfer Area
68-Foot Level Design Response Spectra
East-West Direction

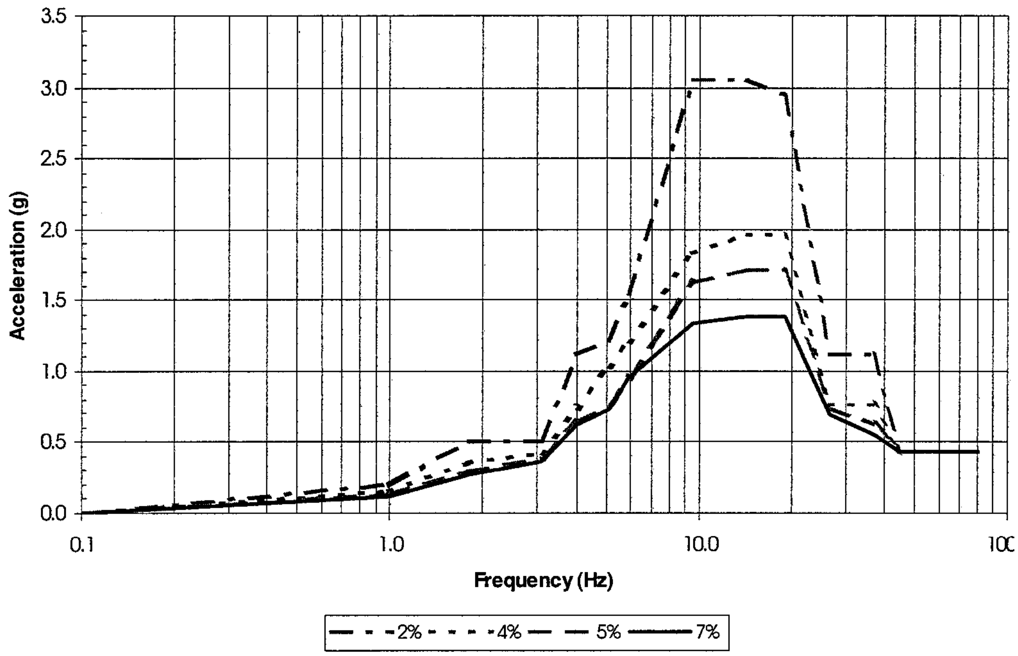


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.10	0.29	0.22	0.20	0.19
1.90	0.76	0.53	0.46	0.38
2.50	0.76	0.53	0.46	0.41
3.60	1.14	0.91	0.74	0.64
4.80	2.32	1.81	1.46	1.38
6.20	4.36	2.79	2.43	1.94
10.00	4.36	2.79	2.43	1.94
14.20	1.38	1.14	1.04	0.90
22.00	0.93	0.70	0.64	0.61
28.00	0.73	0.61	0.59	0.57
47.00	0.50	0.50	0.50	0.50
80.00	0.50	0.50	0.50	0.50

Affected major equipment: Shield door

Figure 3.2-32
Transfer Area
68-Foot Level Design Response Spectra
Vertical Direction

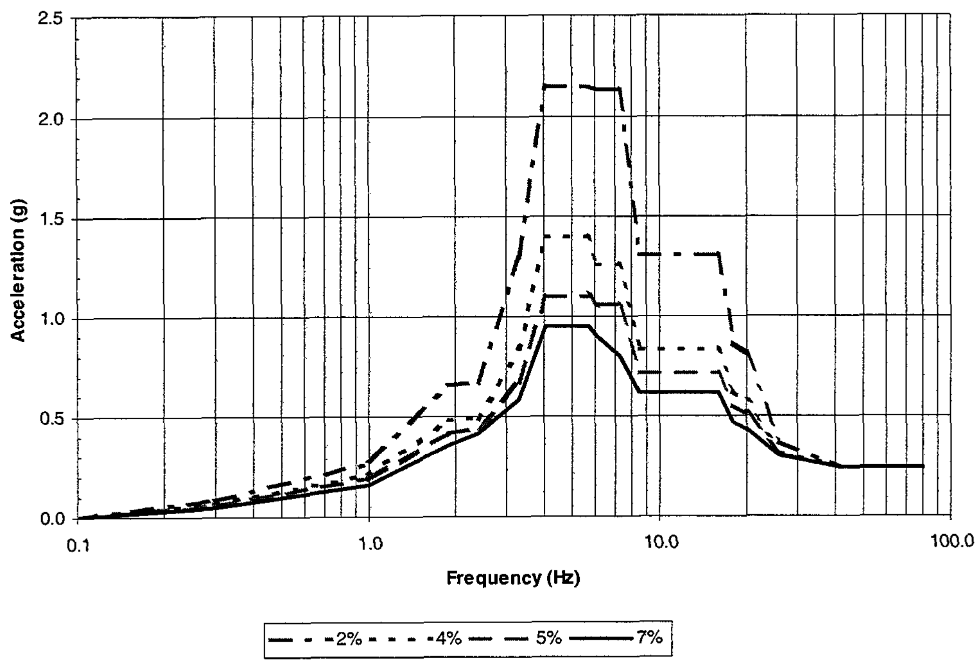


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.80	0.51	0.35	0.29	0.27
3.10	0.51	0.42	0.39	0.36
4.00	1.12	0.74	0.63	0.62
5.10	1.21	1.03	0.75	0.73
5.90	1.54	1.21	0.95	0.95
9.60	3.05	1.83	1.62	1.34
14.30	3.05	1.96	1.71	1.39
19.00	2.95	1.96	1.71	1.39
26.50	1.11	0.76	0.74	0.69
37.00	1.11	0.76	0.62	0.55
45.00	0.43	0.43	0.43	0.43
80.00	0.43	0.43	0.43	0.43

Affected major equipment: Shield door

Figure 3.2-33
Transfer Area
2nd Floor Level CCA Design Response Spectra
North-South Direction

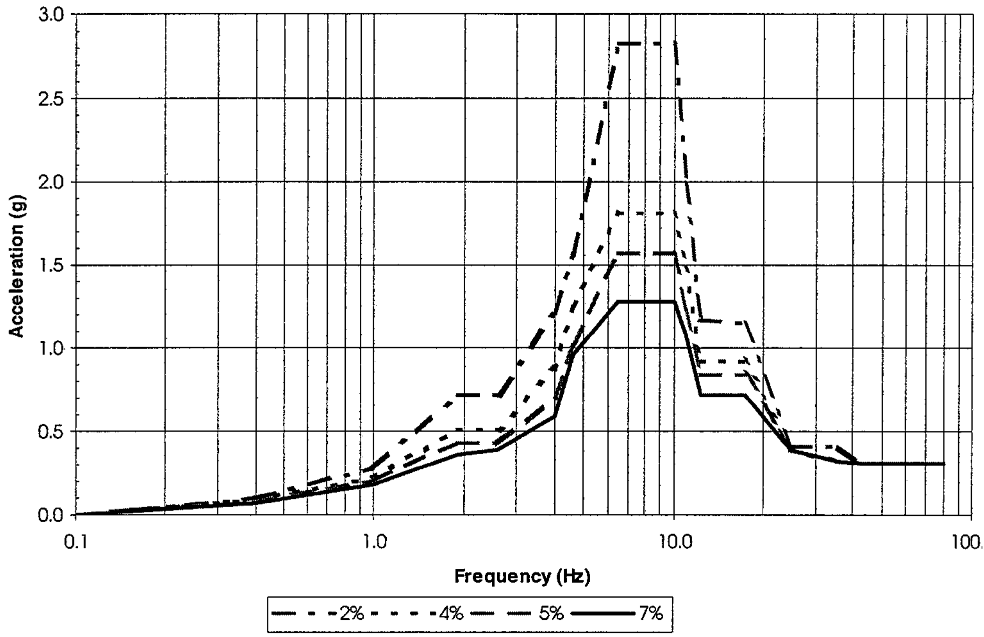


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.27	0.21	0.19	0.16
1.90	0.66	0.48	0.42	0.36
2.40	0.67	0.49	0.44	0.42
3.30	1.29	0.83	0.67	0.58
4.10	2.15	1.40	1.10	0.95
5.70	2.15	1.40	1.10	0.95
6.10	2.13	1.26	1.06	0.90
7.30	2.13	1.26	1.06	0.80
8.50	1.31	0.83	0.72	0.62
16.00	1.31	0.83	0.72	0.62
18.00	0.87	0.62	0.55	0.47
20.00	0.82	0.57	0.51	0.43
26.00	0.37	0.32	0.31	0.30
42.00	0.24	0.24	0.24	0.24
80.00	0.24	0.24	0.24	0.24

Affected major equipment: Canister Closure Area equipment, canister storage rack, canister welding machine

Figure 3.2-34
Transfer Area
2nd Floor Level CCA Design Response Spectra
East-West Direction

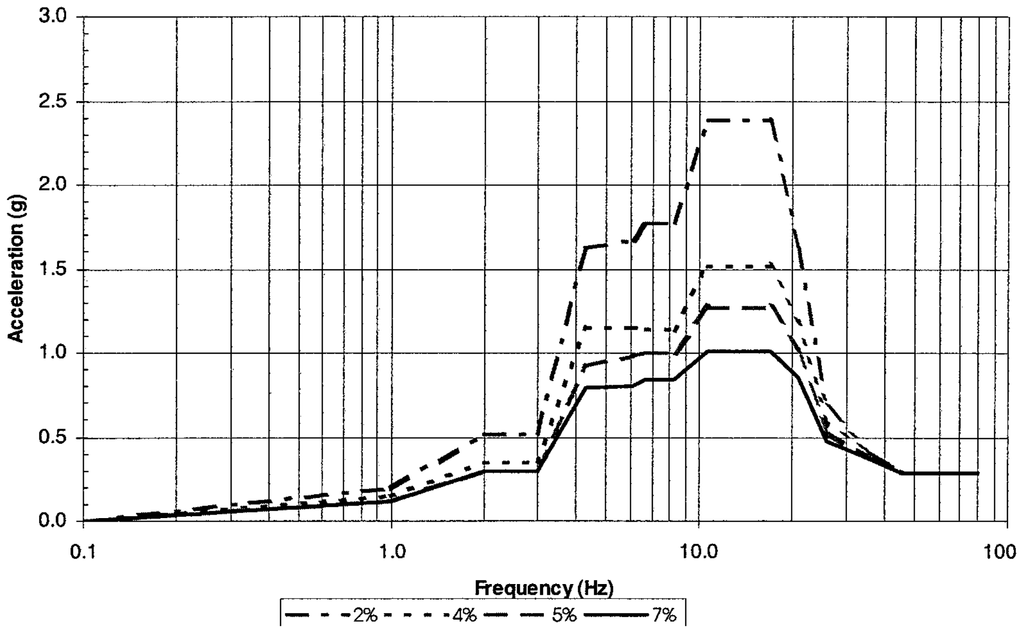


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.28	0.22	0.20	0.18
1.90	0.72	0.51	0.43	0.36
2.60	0.72	0.51	0.43	0.39
4.00	1.21	0.87	0.70	0.59
4.60	1.56	1.25	1.01	0.96
6.50	2.83	1.81	1.57	1.28
10.00	2.83	1.81	1.57	1.28
11.00	1.99	1.48	1.23	1.08
12.30	1.17	0.92	0.84	0.72
17.30	1.15	0.92	0.84	0.72
25.00	0.41	0.39	0.39	0.39
36.00	0.41	0.32	0.32	0.32
43.00	0.31	0.31	0.31	0.31
80.00	0.31	0.31	0.31	0.31

Affected major equipment: Canister Closure Area equipment, canister storage rack, canister welding machine

Figure 3.2-35
Transfer Area
2nd Floor Level CCA Design Response Spectra
Vertical Direction

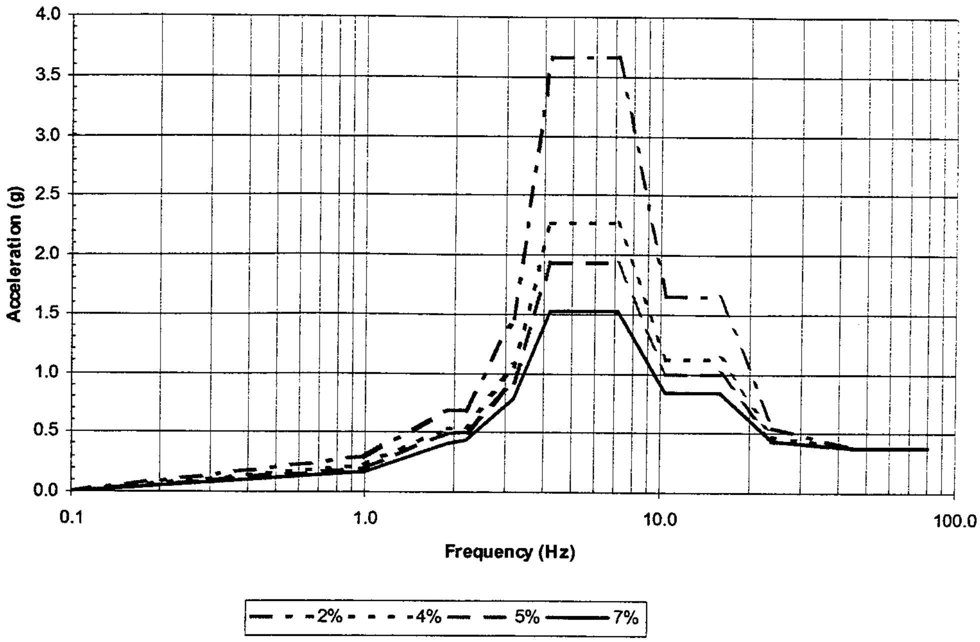


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.12	0.12
2.00	0.51	0.35	0.30	0.30
3.00	0.51	0.35	0.30	0.30
4.30	1.62	1.15	0.92	0.79
6.10	1.67	1.15	0.98	0.80
6.70	1.77	1.14	1.00	0.84
8.30	1.77	1.14	1.00	0.84
10.60	2.39	1.51	1.27	1.01
17.00	2.39	1.51	1.27	1.01
21.00	1.62	1.19	1.02	0.85
26.00	0.67	0.59	0.53	0.48
36.00	0.41	0.39	0.38	0.37
45.00	0.29	0.29	0.29	0.29
80.00	0.29	0.29	0.29	0.29

Affected major equipment: Canister Closure Area equipment, canister storage rack, canister welding machine

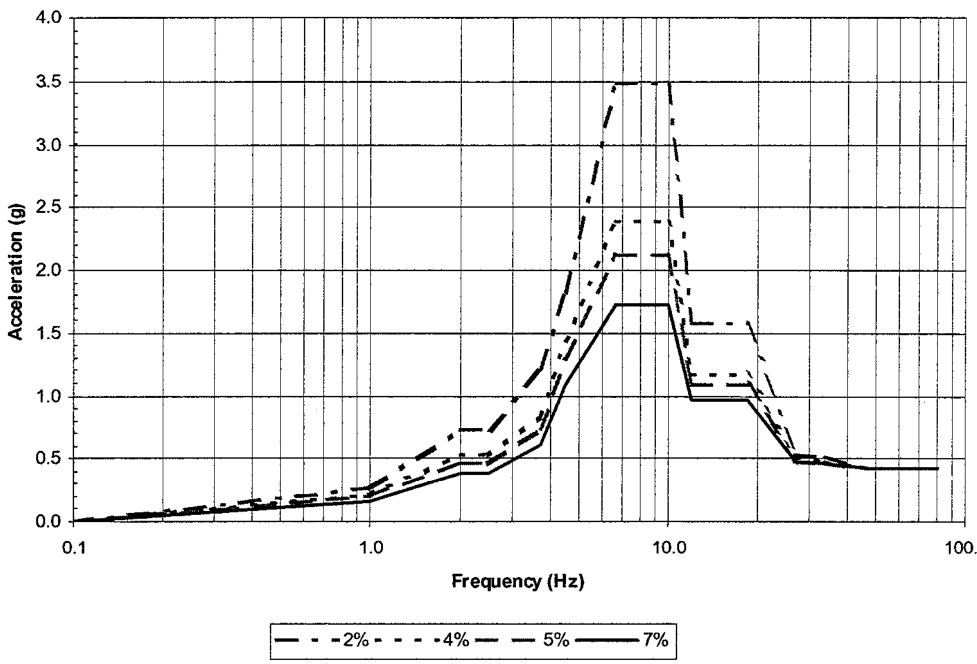
Figure 3.2-36
Transfer Area
CCA Crane Level Design Response Spectra
North-South Direction



North-South Direction				
Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.29	0.22	0.19	0.17
1.90	0.69	0.53	0.49	0.41
2.20	0.68	0.54	0.50	0.43
3.20	1.46	1.05	0.91	0.78
4.20	3.66	2.26	1.93	1.53
7.20	3.66	2.26	1.93	1.53
10.40	1.65	1.12	1.00	0.84
15.80	1.65	1.12	1.00	0.84
24.00	0.55	0.47	0.44	0.44
45.00	0.38	0.38	0.38	0.38
80.00	0.38	0.38	0.38	0.38

Affected major equipment: Canister Closure Area crane

Figure 3.2-37
Transfer Area
CCA Crane Level Design Response Spectra
East-West Direction

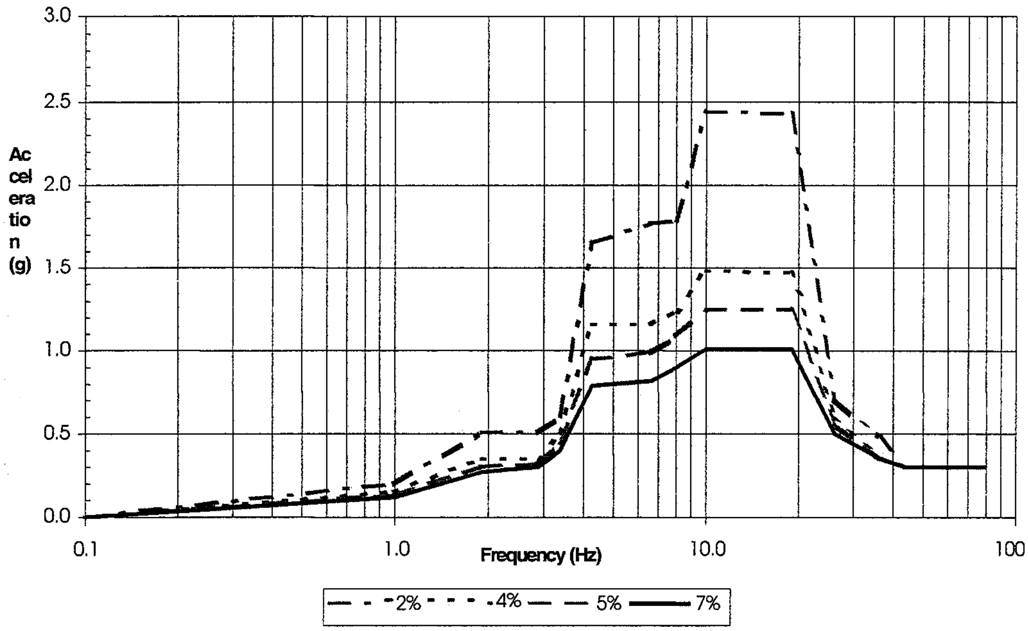


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.27	0.21	0.20	0.16
2.00	0.73	0.53	0.46	0.38
2.50	0.73	0.53	0.46	0.38
3.70	1.20	0.83	0.73	0.61
4.50	1.81	1.43	1.29	1.09
6.60	3.48	2.39	2.12	1.72
10.00	3.48	2.39	2.12	1.72
12.00	1.58	1.16	1.08	0.97
18.50	1.58	1.16	1.08	0.97
27.00	0.53	0.50	0.48	0.48
34.00	0.52	0.48	0.47	0.47
47.00	0.43	0.43	0.43	0.43
80.00	0.43	0.43	0.43	0.43

Affected major equipment: Canister Closure Area crane

Figure 3.2-38
Transfer Area
CCA Crane Level Design Response Spectra
Vertical Direction

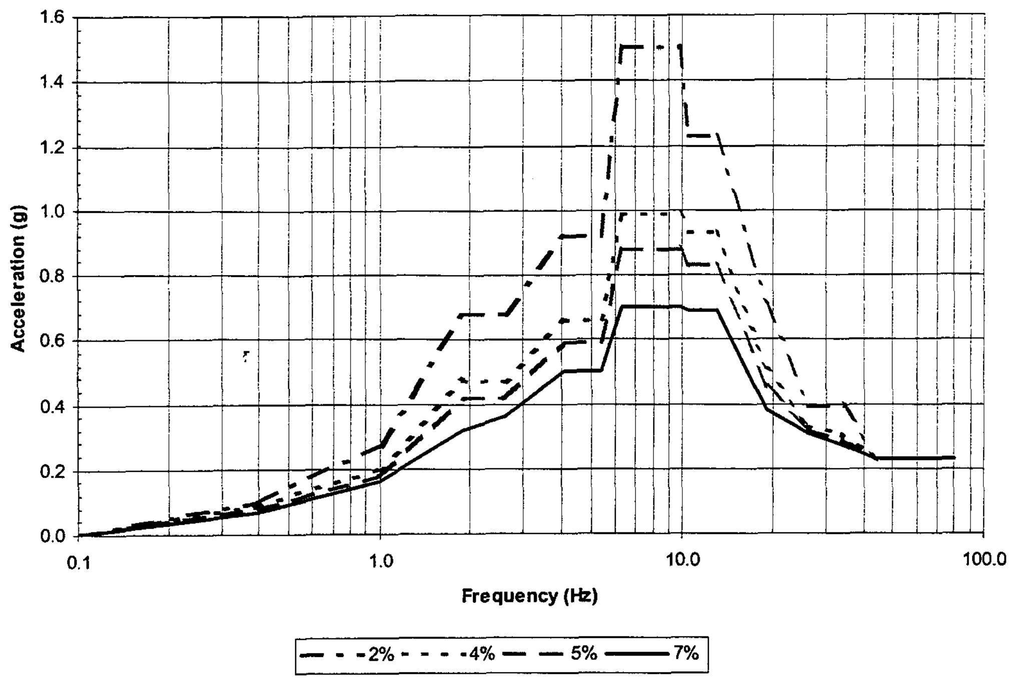


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.90	0.51	0.35	0.30	0.27
2.90	0.51	0.35	0.32	0.30
3.40	0.60	0.50	0.44	0.40
4.30	1.65	1.16	0.95	0.79
6.70	1.77	1.16	0.99	0.82
8.00	1.78	1.24	1.09	0.90
10.00	2.44	1.48	1.25	1.01
19.00	2.44	1.47	1.25	1.01
26.00	0.71	0.60	0.56	0.50
36.00	0.48	0.36	0.36	0.36
44.00	0.30	0.30	0.30	0.30
80.00	0.30	0.30	0.30	0.30

Affected major equipment: Canister Closure Area crane

Figure 3.2-39
Storage Area
Base Mat Design Response Spectra
East-West Direction

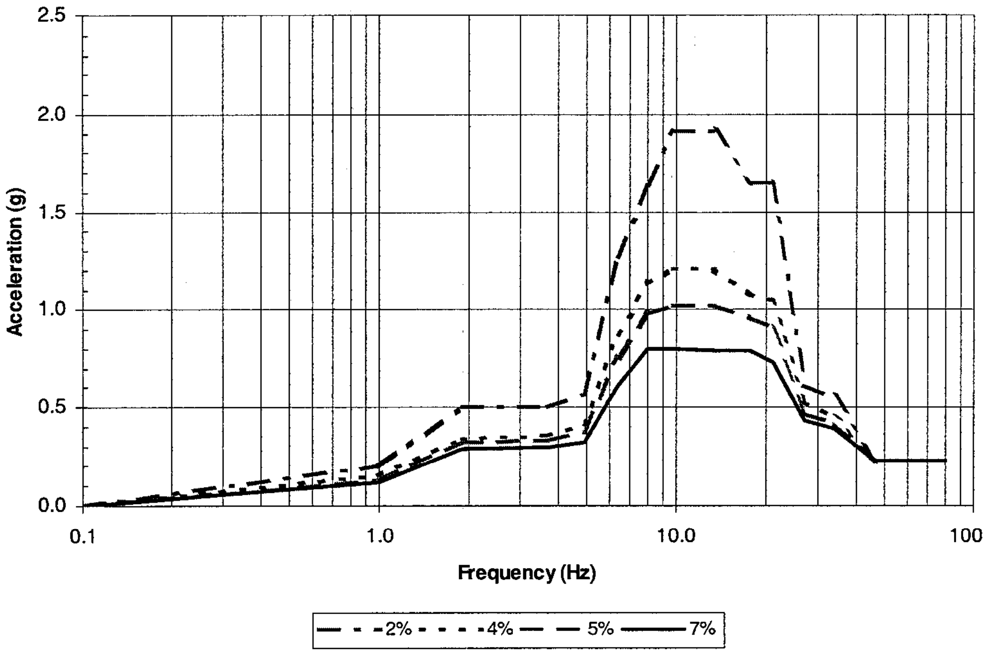


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.27	0.20	0.18	0.16
1.90	0.68	0.47	0.42	0.32
2.60	0.68	0.47	0.42	0.36
4.10	0.92	0.66	0.59	0.50
5.40	0.92	0.66	0.59	0.50
6.30	1.50	0.99	0.88	0.70
9.80	1.50	0.99	0.88	0.70
10.50	1.23	0.93	0.83	0.69
13.00	1.23	0.93	0.83	0.69
19.00	0.71	0.50	0.45	0.38
26.00	0.39	0.33	0.32	0.31
34.00	0.39	0.31	0.29	0.27
44.00	0.23	0.23	0.23	0.23
80.00	0.23	0.23	0.23	0.23

Affected major equipment: Building structure

Figure 3.2-40
Storage Area
Base Mat Design Response Spectra
Vertical Direction

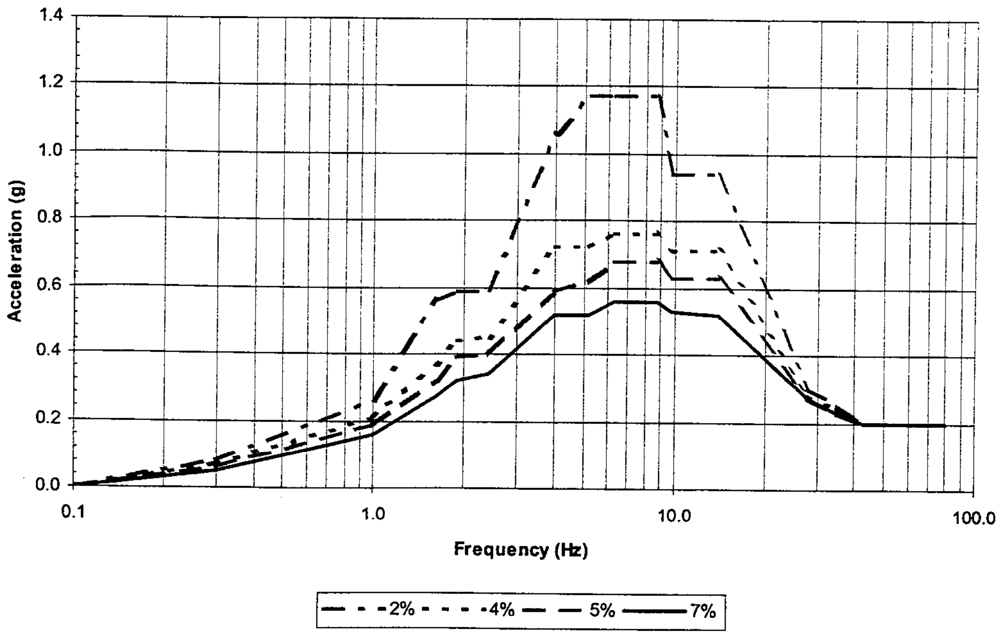


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.90	0.50	0.34	0.32	0.29
3.70	0.50	0.36	0.33	0.30
4.90	0.57	0.41	0.37	0.32
6.40	1.27	0.88	0.76	0.61
8.00	1.63	1.13	0.98	0.80
9.80	1.91	1.21	1.02	0.80
13.40	1.91	1.21	1.02	0.79
17.60	1.65	1.08	0.96	0.79
21.00	1.65	1.05	0.91	0.73
27.00	0.61	0.53	0.47	0.43
34.00	0.55	0.44	0.42	0.39
46.00	0.23	0.23	0.23	0.23
80.00	0.23	0.23	0.23	0.23

Affected major equipment: Building structure

Figure 3.2-41
Storage Area/Transfer Area
Tunnel Level Design Response Spectra
North-South Direction

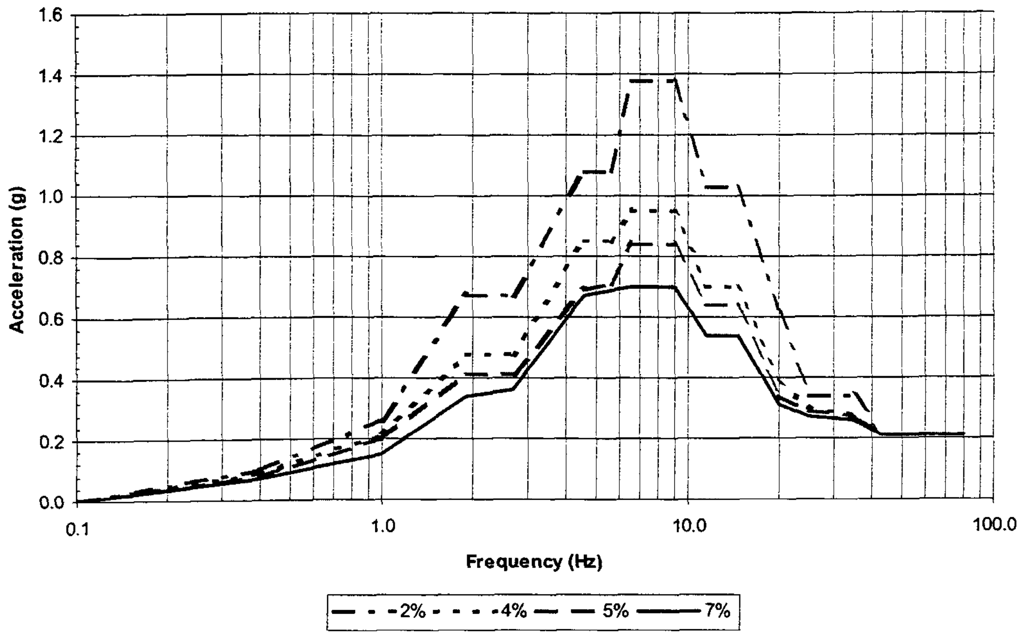


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.56	0.37	0.32	0.27
1.90	0.59	0.44	0.39	0.32
2.40	0.59	0.45	0.40	0.34
4.00	1.06	0.72	0.59	0.52
5.20	1.17	0.72	0.62	0.52
6.30	1.17	0.76	0.68	0.56
8.70	1.17	0.76	0.68	0.56
9.80	0.94	0.71	0.63	0.53
14.00	0.94	0.71	0.63	0.52
28.00	0.30	0.28	0.27	0.27
35.00	0.25	0.24	0.23	0.23
43.00	0.20	0.20	0.20	0.20
80.00	0.20	0.20	0.20	0.20

Affected major equipment: Cask trolley, canister trolley

Figure 3.2-42
Storage Area/Transfer Area
Tunnel Level Design Response Spectra
East-West Direction

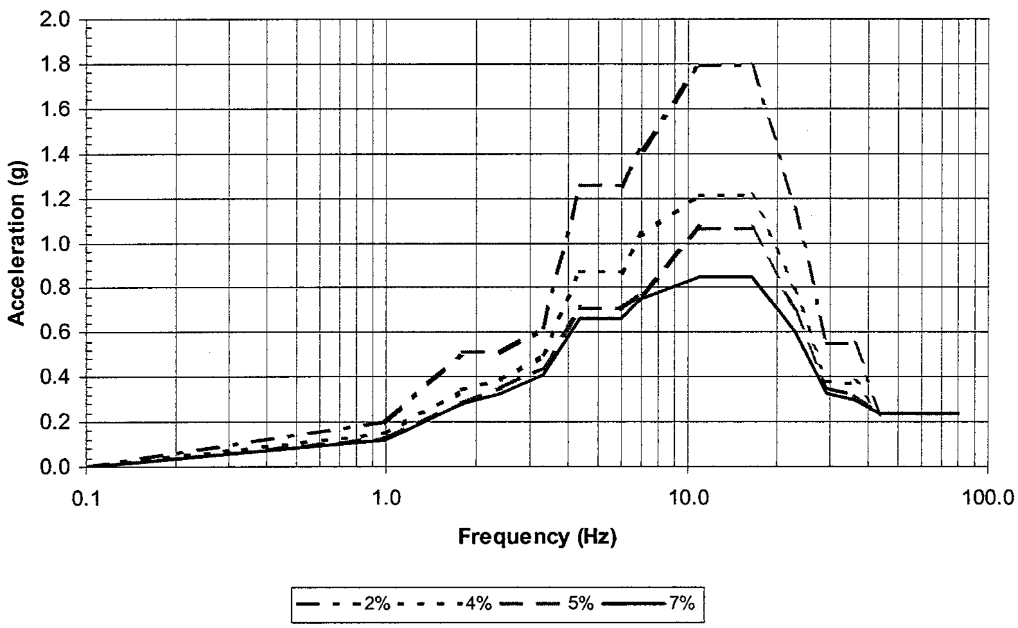


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.26	0.21	0.20	0.15
1.90	0.67	0.48	0.41	0.34
2.70	0.67	0.48	0.41	0.36
4.60	1.08	0.85	0.69	0.67
5.60	1.08	0.85	0.71	0.69
6.50	1.38	0.95	0.84	0.70
9.00	1.38	0.95	0.84	0.70
11.50	1.03	0.70	0.64	0.54
14.50	1.03	0.70	0.64	0.54
20.00	0.62	0.39	0.34	0.31
25.00	0.34	0.30	0.29	0.27
35.00	0.34	0.28	0.27	0.26
43.00	0.21	0.21	0.21	0.21
80.00	0.21	0.21	0.21	0.21

Affected major equipment: Cask trolley, canister trolley

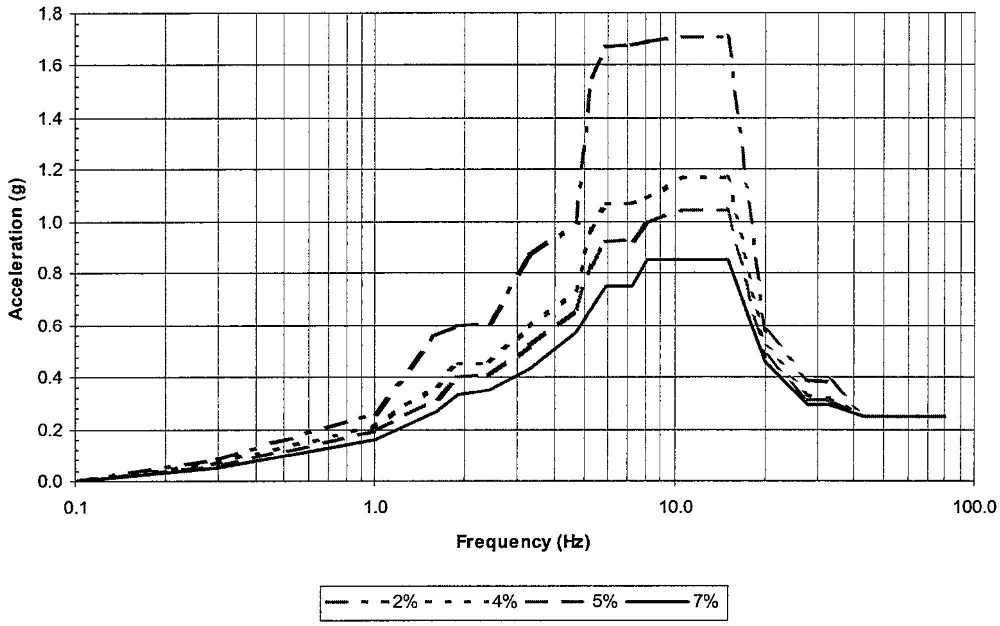
Figure 3.2-43
Storage Area/Transfer Area
Tunnel Level Design Response Spectra
Vertical Direction



Vertical Direction				
Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
1.80	0.51	0.34	0.28	0.28
2.40	0.51	0.39	0.35	0.33
3.30	0.62	0.50	0.44	0.41
4.40	1.26	0.87	0.71	0.66
6.00	1.26	0.87	0.71	0.66
7.00	1.42	1.03	0.77	0.75
11.00	1.79	1.21	1.06	0.85
16.50	1.79	1.21	1.06	0.85
23.00	1.15	0.79	0.70	0.60
29.00	0.55	0.38	0.35	0.33
36.00	0.55	0.37	0.32	0.30
44.00	0.24	0.24	0.24	0.24
80.00	0.24	0.24	0.24	0.24

Affected major equipment: Cask trolley, canister trolley

Figure 3.2-44
Storage Area
Charge Face Level Design Response Spectra
North-South Direction

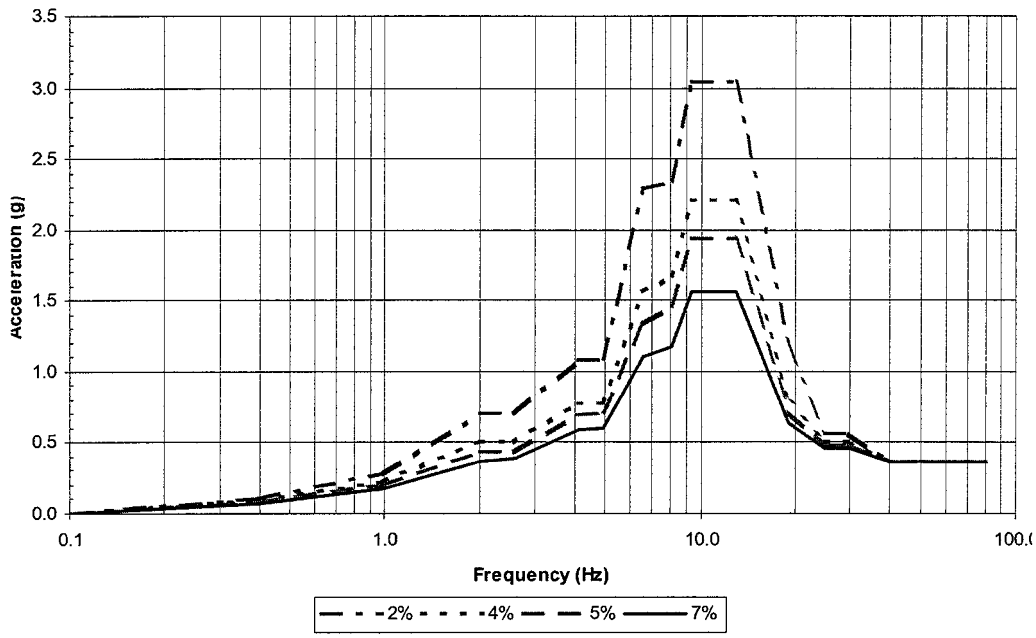


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.56	0.37	0.32	0.27
1.90	0.60	0.45	0.40	0.33
2.40	0.61	0.45	0.41	0.35
3.30	0.87	0.60	0.52	0.43
4.70	0.99	0.73	0.66	0.57
5.30	1.55	0.97	0.83	0.66
5.90	1.67	1.07	0.92	0.75
7.20	1.68	1.07	0.93	0.75
8.10	1.69	1.09	0.99	0.85
10.50	1.71	1.17	1.04	0.85
15.00	1.71	1.17	1.04	0.85
20.00	0.57	0.51	0.48	0.46
28.00	0.39	0.33	0.31	0.29
33.00	0.38	0.32	0.31	0.29
43.00	0.25	0.25	0.25	0.25
80.00	0.25	0.25	0.25	0.25

Affected major equipment: Storage tube top

Figure 3.2-45
Storage Area
Charge Face Level Design Response Spectra
East-West Direction

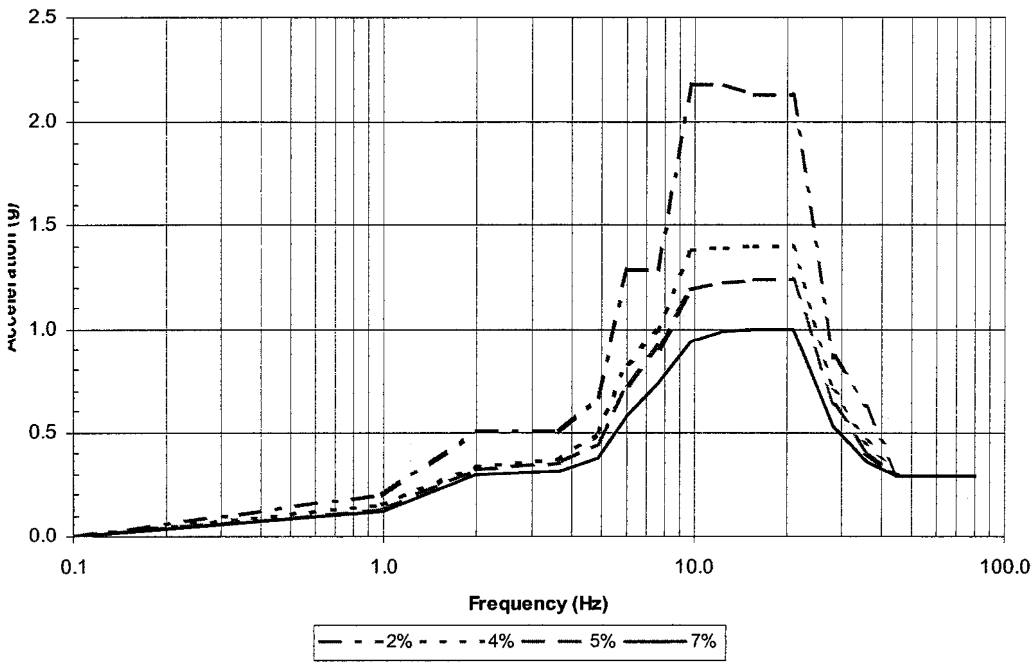


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.28	0.22	0.20	0.18
2.00	0.70	0.50	0.44	0.36
2.60	0.70	0.50	0.44	0.39
4.10	1.08	0.77	0.69	0.59
4.90	1.08	0.78	0.71	0.60
6.60	2.29	1.56	1.34	1.10
8.10	2.34	1.67	1.46	1.17
9.30	3.04	2.21	1.94	1.56
13.00	3.04	2.21	1.94	1.56
19.00	1.18	0.78	0.72	0.64
25.00	0.56	0.50	0.48	0.46
30.00	0.56	0.50	0.48	0.46
40.00	0.36	0.36	0.36	0.36
80.00	0.36	0.36	0.36	0.36

Affected major equipment: Storage tube top

Figure 3.2-46
Storage Area
Charge Face Level Design Response Spectra
Vertical Direction

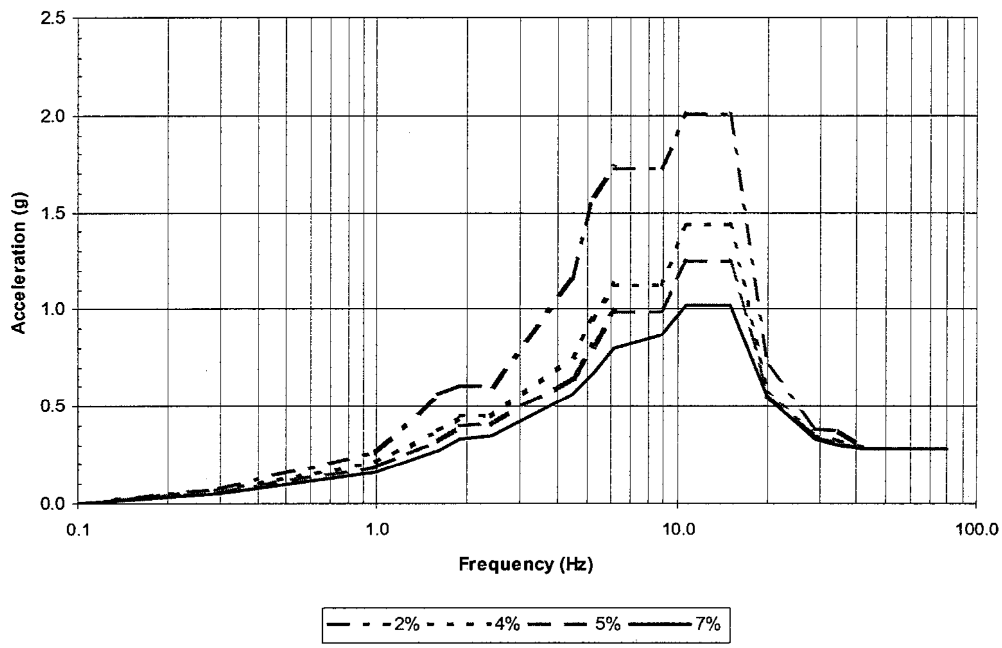


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
2.00	0.51	0.34	0.32	0.30
3.70	0.51	0.37	0.35	0.31
4.90	0.67	0.50	0.44	0.38
6.00	1.29	0.84	0.73	0.58
7.60	1.29	0.99	0.91	0.74
9.80	2.18	1.38	1.19	0.94
12.50	2.18	1.39	1.22	0.99
15.50	2.13	1.40	1.24	1.00
21.00	2.13	1.40	1.24	1.00
28.00	0.86	0.69	0.63	0.53
36.00	0.63	0.45	0.41	0.36
45.00	0.29	0.29	0.29	0.29
80.00	0.29	0.29	0.29	0.29

Affected major equipment: Storage tube top

Figure 3.2-47
Storage Area
CHM Level Design Response Spectra
North-South Direction

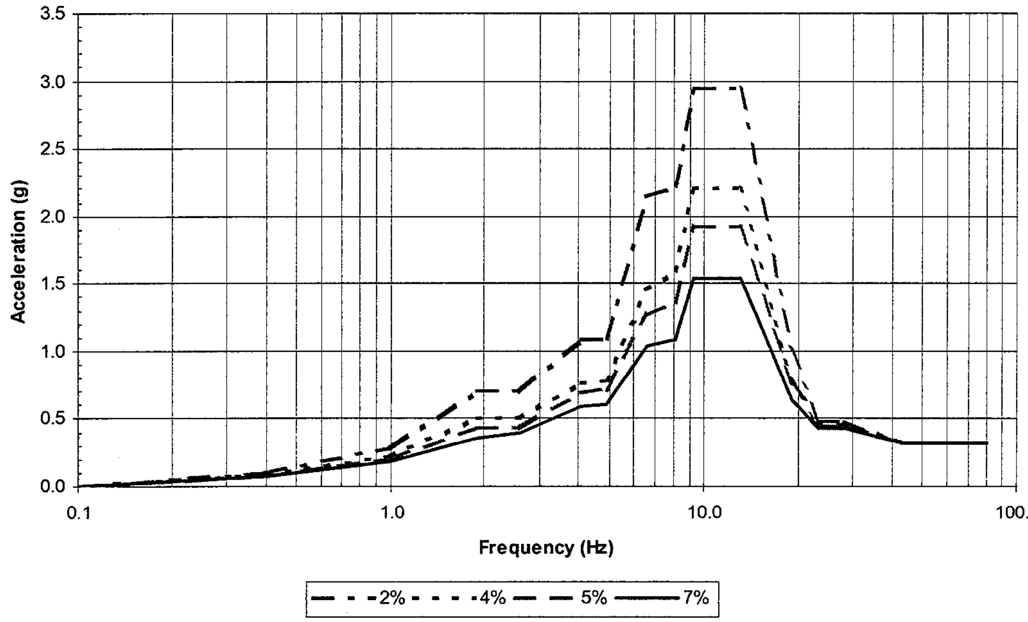


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.56	0.37	0.32	0.27
1.90	0.60	0.45	0.40	0.33
2.40	0.60	0.45	0.41	0.35
4.50	1.16	0.75	0.65	0.56
5.20	1.59	0.95	0.81	0.66
6.10	1.73	1.12	0.99	0.80
8.80	1.73	1.12	0.99	0.87
10.70	2.01	1.44	1.25	1.02
15.00	2.01	1.44	1.25	1.02
20.00	0.70	0.58	0.56	0.54
29.00	0.38	0.35	0.34	0.33
35.00	0.37	0.32	0.31	0.30
43.00	0.28	0.28	0.28	0.28
80.00	0.28	0.28	0.28	0.28

Affected major equipment: Canister handling machine

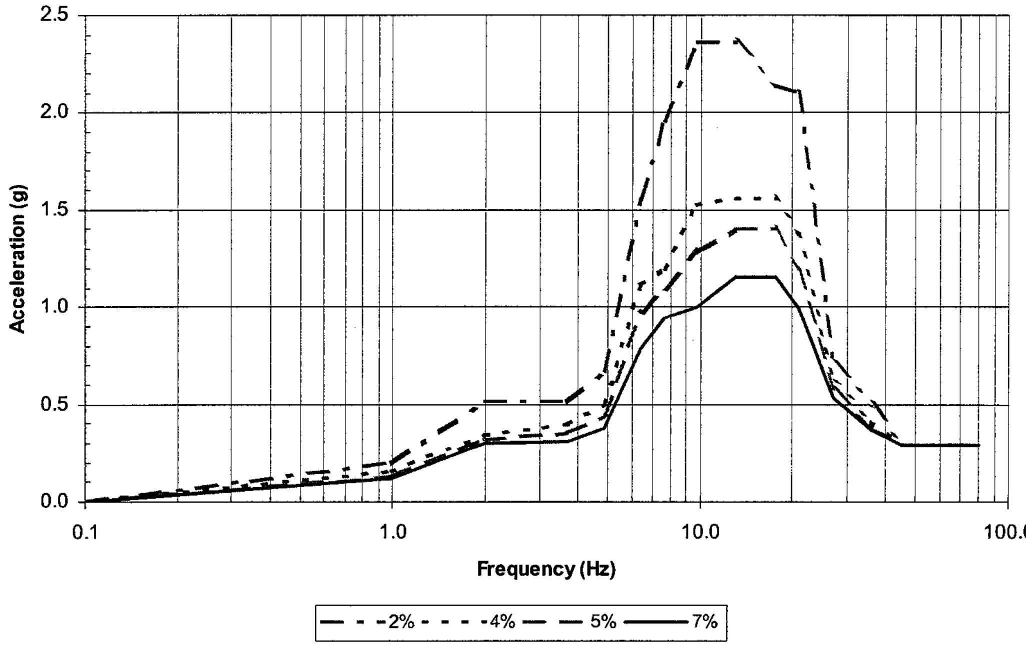
Figure 3.2-48
Storage Area
CHM Level Design Response Spectra
East-West Direction



East-West Direction				
Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.28	0.22	0.20	0.18
1.90	0.70	0.50	0.43	0.36
2.60	0.70	0.50	0.43	0.39
4.10	1.08	0.77	0.69	0.59
4.90	1.08	0.78	0.71	0.60
6.60	2.15	1.45	1.26	1.04
8.10	2.22	1.59	1.36	1.08
9.30	2.95	2.21	1.92	1.54
13.10	2.95	2.21	1.92	1.54
19.00	1.01	0.78	0.75	0.64
23.00	0.48	0.45	0.44	0.43
28.00	0.48	0.45	0.44	0.43
43.00	0.32	0.32	0.32	0.32
80.00	0.32	0.32	0.32	0.32

Affected major equipment: Canister handling machine

Figure 3.2-49
Storage Area
CHM Level Design Response Spectra
Vertical Direction

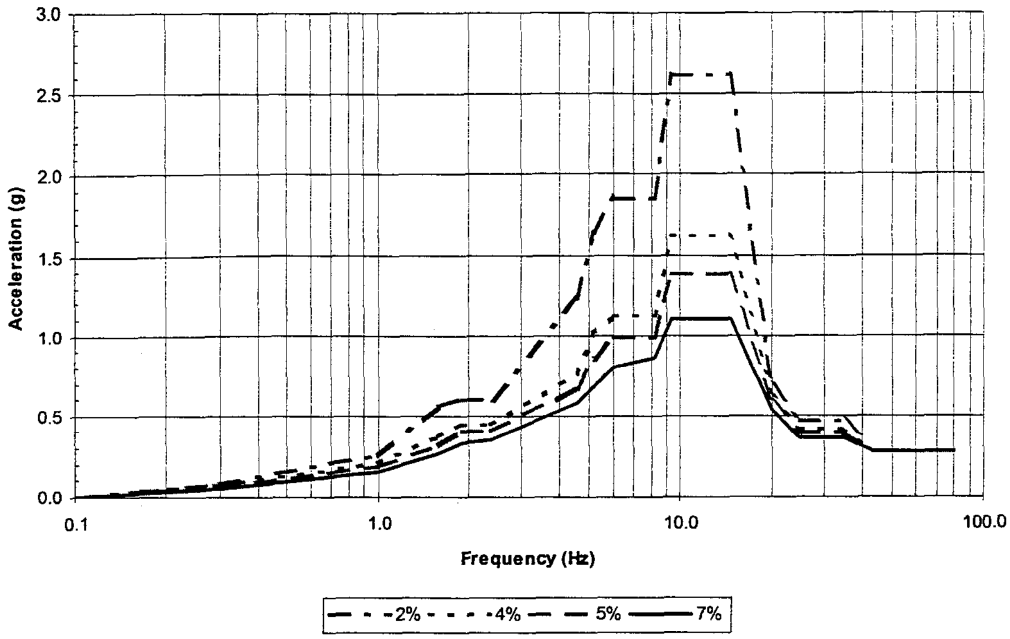


Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
2.00	0.51	0.34	0.32	0.30
3.70	0.51	0.39	0.35	0.31
4.90	0.67	0.50	0.44	0.38
6.40	1.55	1.11	0.98	0.79
7.60	1.95	1.20	1.10	0.94
9.80	2.36	1.52	1.28	1.00
13.00	2.36	1.56	1.40	1.16
17.60	2.14	1.56	1.40	1.16
21.00	2.11	1.38	1.20	0.99
27.00	0.71	0.61	0.57	0.53
36.00	0.50	0.41	0.38	0.37
45.00	0.29	0.29	0.29	0.29
80.00	0.29	0.29	0.29	0.29

Affected major equipment: Canister handling machine

Figure 3.2-50
Storage Area
Parapet Wall Level Design Response Spectra
North-South Direction

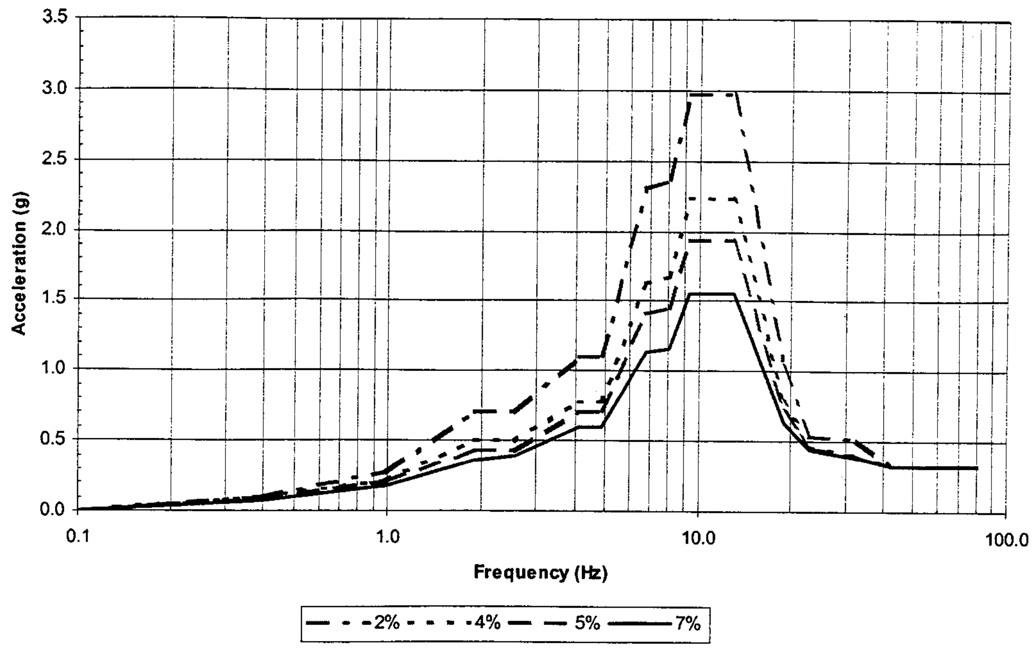


North-South Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.30	0.08	0.07	0.06	0.05
1.00	0.26	0.21	0.19	0.16
1.60	0.56	0.37	0.32	0.27
1.90	0.60	0.45	0.40	0.33
2.40	0.60	0.45	0.41	0.35
4.60	1.22	0.76	0.67	0.58
5.20	1.64	1.02	0.85	0.68
6.00	1.85	1.12	0.99	0.80
8.30	1.85	1.12	0.99	0.86
9.40	2.62	1.62	1.38	1.10
14.70	2.62	1.62	1.38	1.10
20.00	0.69	0.61	0.58	0.54
25.00	0.47	0.42	0.39	0.36
35.00	0.47	0.42	0.39	0.36
43.00	0.28	0.28	0.28	0.28
80.00	0.28	0.28	0.28	0.28

Affected major equipment: Structural steel

Figure 3.2-51
Storage Area
Parapet Wall Level Design Response Spectra
East-West Direction

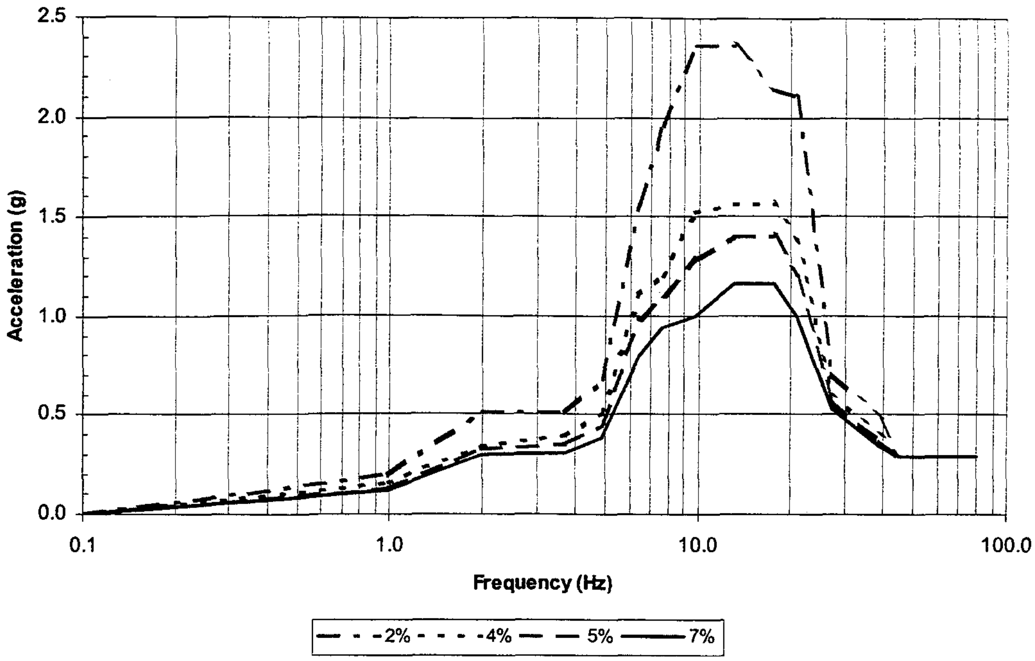


East-West Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
0.40	0.10	0.09	0.08	0.07
1.00	0.28	0.22	0.20	0.18
1.90	0.70	0.50	0.43	0.36
2.60	0.70	0.50	0.43	0.39
4.10	1.10	0.78	0.71	0.60
4.90	1.10	0.78	0.71	0.60
6.80	2.31	1.62	1.41	1.13
8.10	2.36	1.67	1.45	1.16
9.30	2.98	2.23	1.94	1.55
13.00	2.98	2.23	1.94	1.55
19.00	1.04	0.78	0.71	0.63
23.00	0.54	0.47	0.45	0.44
33.00	0.51	0.40	0.39	0.38
43.00	0.32	0.32	0.32	0.32
80.00	0.32	0.32	0.32	0.32

Affected major equipment: Structural steel

Figure 3.2-52
Storage Area
Parapet Wall Level Design Response Spectra
Vertical Direction



Vertical Direction

Frequency	0.02	0.04	0.05	0.07
0.10	0.00	0.00	0.00	0.00
1.00	0.20	0.15	0.13	0.12
2.00	0.51	0.34	0.32	0.30
3.70	0.51	0.39	0.35	0.31
4.90	0.67	0.50	0.44	0.38
6.40	1.55	1.11	0.98	0.79
7.60	1.95	1.20	1.10	0.94
9.80	2.36	1.52	1.28	1.00
13.00	2.36	1.56	1.40	1.16
17.60	2.14	1.56	1.40	1.16
21.00	2.11	1.38	1.20	0.99
27.00	0.71	0.61	0.57	0.53
39.00	0.48	0.39	0.37	0.34
45.00	0.29	0.29	0.29	0.29
80.00	0.29	0.29	0.29	0.29

Affected major equipment: Structural steel